CHAPTER 7: LEAD-BASED PAINT INSPECTION

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Lead-Based Paint Inspection: How To Do It

1. Determine if lead-based paint inspections should be done (see Chapter 5). A lead-based paint inspection will answer the following two questions: (1) Is there lead-based paint in the dwelling unit, common areas, or building exterior and (2) if lead-based paint is present, where is it located?

2. Hire a qualified lead-based paint inspector (certified inspector technician) and select an accredited laboratory for paint-chip analysis (if necessary). Some local jurisdictions require a license or certification to perform a lead-based paint inspection. Certification is usually carried out by State governments. The laboratory should be one that is recognized by the U.S. Environmental Protection Agency (EPA) through EPA's National Lead Laboratory Accreditation Program (NLLAP).

3. Determine whether to use the standard of 1.0 mg/cm^2 or 0.5 percent by weight or a combination of the two. Measuring against 1.0 mg/cm^2 can be achieved by x-ray fluorescence (XRF) instrument readings followed by laboratory confirmation where necessary. However, the 0.5 percent by weight standard can be achieved only through laboratory analysis. These guidelines recommend using the mg/cm^2 standard except when it is not possible for technical reasons.

4. Refer to the *XRF Performance Characteristics Sheet* for the specific XRF instruments used. The *XRF Per-formance Characteristics Sheet* will specify an inconclusive range, calibration check tolerance, and other instrument-specific information. Contact the National Lead Information Center Clearinghouse (1–800–424–LEAD) to obtain the appropriate *XRF Performance Characteristics Sheet*.

5. Observe radiation safety procedures when using XRF instruments. During XRF testing pay particular attention to walls, ceilings, and floors that are adjacent to neighboring units.

6. When conducting a multifamily inspection, obtain a complete list of all housing units and determine which units can be grouped for inspection purposes based on similarity of construction materials and common painting histories. In each group of similar units, the inspector should determine the minimum number to be inspected from the tables in this chapter and randomly select the specific units to be tested. Select common areas, exterior building sides, and exterior site areas associated with the selected units.

7. For each unit to be inspected, the inspector should inventory all painted components in each room, selected common areas, exterior side, and exterior areas. Painted surfaces include any surface coated with paint, shellac, varnish, stain, coating, or paint covered by wallpaper. Select the specific components to be tested.

8. The nominal length of XRF reading times depends on the specific XRF instrument and can be determined by consulting its *XRF Performance Characteristics Sheet*. The reading time increases as the XRF instrument's radioactive source decays.

9. Conduct XRF testing in each unit or house, beginning with at least three calibration check readings. Additional calibration check readings should be made after the inspection has been completed in each unit or house or every 4 hours, whichever occurs first. Calibration check tolerances are obtained from the *XRF Performance Characteristics Sheet*.

10. In single-family housing, XRF testing for lead-based paint requires three readings for each testing combination. A unique testing combination is characterized by the room equivalent, the component, the substrate, and the visible color of the paint. The average of the three readings is then used for determining the presence or absence of lead-based paint. Each reading is taken on a *different* spot, not the same spot as was previously recommended in the 1990 *Interim Guidelines for Public and Indian Housing*.

11. For inspections in multifamily housing, only one reading is required per testing combination.

12. Before evaluating results, determine whether or not to correct the XRF readings for substrate interference by consulting the *XRF Performance Characteristics Sheet*. The correction value is an average of six readings taken on two randomly selected locations (three readings on each location) in a single-family house or in two units in a multifamily development for each type of substrate. The reading should be taken on a surface that has been scraped clean of paint.

13. In single-family housing inspections, XRF results are evaluated to determine if the readings are negative, positive, or inconclusive based on the *XRF Performance Characteristics Sheet* for each specific XRF instrument. All inconclusive readings must be confirmed in the laboratory.

14. In multifamily dwelling inspections, XRF readings are evaluated using the same rules as those for single-family housing and then they are aggregated across units by component type. Use the flowchart provided in this chapter to make final classifications based on the percentages of positive, negative, and inconclusive readings on component types. Paint-chip samples should be sent to the laboratory for confirmation analysis when the overall results for a component type are inconclusive.

15. If it is necessary to collect paint-chip samples, the owner should determine who will collect the samples. The paint-chip samples may be collected by the inspector, a third party, or perhaps the owner. The paint-chip samples should contain all layers of paint with a minimal amount of substrate included. Paint from 4 square inches should provide a sufficient quantity for laboratory analysis.

16. The owner should evaluate the quality of the inspection using the procedures in this chapter before making the final payment.

17. The inspection report should include a summary indicating if and where lead-based paint is located in the unit and the inspection forms that contain the XRF readings, the calibration check test results forms, and laboratory results, if any. The forms in this chapter or comparable forms can be used for this purpose.

CHAPTER 7: LEAD-BASED PAINT INSPECTION

I. Sources of Information and Purpose

This chapter explains methods for carrying out lead-based paint inspections in housing. For purposes of these *Guidelines*, the term lead-based paint means paint or other surface coatings that contain lead equal to or greater than 1.0 mg/cm^2 or 0.5 percent by weight (5,000 µg/g or 5,000 ppm by weight). The complete set of forms provided at the end of this chapter (or comparable forms) may be used in inspecting both single-family and, multifamily housing, and is also appropriate for both public and private housing.

The following sources of additional information should be consulted before undertaking an inspection:

- Lists of certified inspectors are often available from State or local agencies. Call the National Lead Information Center Clearinghouse (1–800–424–LEAD) to locate the appropriate local contact.
- The National Lead Information Center Clearinghouse also provides two documents: 1) a list of laboratories that are recognized by the U.S. Environmental Protection Agency (EPA) National Lead Laboratory Accreditation Program (NLLAP), and 2) the *XRF Performance Characteristics Sheet* for information about each specific portable x-ray fluorescence (XRF) instrument. The *XRF Performance Characteristics Sheet* has been developed by HUD and EPA to help both operators and purchasers of XRF portable lead-based paint analyzers.
- As of this writing, the National Lead Abatement Council (301–924–5490) plans to establish a registry of proficient XRF operators under a grant from HUD.
- Contact the American Society for Testing and Materials (ASTM) (215–299–5585) for two documents: 1) ASTM ES 28–94 for details on collection of paint-chip samples, and 2) ASTM ES 37–94 for details on laboratory preparation of paint-chip samples.
- State radiation protection agencies can be contacted for regulations governing portable XRF instruments.

The paint-chip sampling and measurement techniques used for paint inspection are similar to the techniques used for risk assessment explained in Chapter 5. However, the number of measurements or samples taken for a complete paint inspection will, in most cases, be considerably more than the number of samples required for a risk assessment, because the number of painted surfaces is far greater than the number of surfaces with deteriorated paint. Risk assessments focus primarily on deteriorated lead-based paint and other lead-based paint hazards, while the paint inspection of a dwelling will provide answers to the following two questions:

- Is there lead-based paint in the dwelling units, common areas, or building exterior?
- If lead-based paint is present, where is it located?

II. Introduction

All paint inspections may be carried out using paint-chip sampling and laboratory analysis, at the option of the purchaser of inspection services. However, this option is not recommended because it is time-consuming, costly, and requires extensive repairs of painted surfaces. The recommended primary method for measuring the lead level in paint is with a portable XRF instrument manufactured for paint analysis.

Portable XRF instruments expose the painted surface to X rays or other high-energy radiation (such as gamma rays), which causes lead to emit X rays with a characteristic frequency. The intensity of this radiation is measured by the instrument's detector and is then converted into a number that represents the amount of lead in the paint per unit area, usually milligrams per square centimeter (mg/cm^2). The result will appear on the display area of the instrument and is called an XRF reading. Laboratory analysis of paint-chip samples is recommended for components that cannot be tested using XRF instruments, and is also recommended to confirm inconclusive XRF results.

The *XRF Performance Characteristics Sheet* provides information necessary to conduct an inspection of lead-based paint using specific XRF instruments. HUD recommends that only those XRF instruments listed in an *XRF Performance Characteristics Sheet* be used. Detailed information regarding XRF readings taken on specific substrates, calibration check tolerances, and information describing the performance of each instrument is provided for specific models of XRF instruments. The single-family and multifamily inspection examples found later in this chapter are based on information provided in the *XRF Performance Characteristics Sheet.*

For the most part, these *Guidelines* are consistent with XRF instrument manufacturers' instructions. Where there are discrepancies on substrate correction, inconclusive ranges, or other issues, HUD recommends that the procedures explained in this chapter be followed. These procedures are based on independent research funded by EPA and HUD and represent the best judgments of experts in the field.

These *Guidelines* are applicable to all XRF instruments that detect K X rays, L X rays, or both. XRF instruments direct high-energy photons (such as X rays or gamma rays) into paint that impinge on the lead atom and ultimately cause electrons from the K- or L-shells to be ejected. This produces X rays with energy characteristics of the K- or L-shell orbits. Emission of this energy is called fluorescence. The amount of fluorescence can be used to quantitatively measure lead.

The L-shell fluorescence (x-ray energy) has longer wavelengths (and therefore lower energy) than those released from K-shell orbits. As a result, L X rays released from greater depths of paint are less likely to reach the surface than are K X rays. Therefore, depending on the number and thickness of the paint layers, XRF instruments may have more difficulty quantitatively detecting L X rays than K X rays. Since lead is often found in primer and older paint layers, XRF measurements based on L X rays alone may underestimate the amount of lead in paint for the following reason. The failure to detect X rays originating in the deeper layers of paint can be a major source of error. For those instruments that use L X rays, the *XRF Performance Characteristics Sheet* describes the magnitude of the error for each instrument.

Instruments using K X rays also have some degree of error, since they can penetrate deeply and "see" materials behind the paint, such as nails, pipes, and substrates. Based on current evidence, this source of error is much smaller than the error associated with instruments that use L X rays.

The advantages of XRF testing are *speed* (results are immediately available), *cost-efficiency* (as compared to laboratory analysis), and *non-destructiveness* (the painted surface is not damaged by XRF testing). However, XRF measurements may have a relatively large margin of error compared to laboratory analysis, and XRF instruments should not be used to test highly curved or ornate surfaces due to safety concerns, poor reliability of the results, and inability to determine surface area exactly. To deal with these problems, laboratory analysis of paint-chip samples by a laboratory recognized by the NLLAP is recommended. Section VI of this chapter provides additional information about these laboratories.

Laboratory analysis is more accurate and precise than XRF readings, and should be used when an XRF result is inconclusive, and wherever an XRF reading cannot be taken due to an irregular or inaccessible surface. Since laboratory analysis is time consuming, relatively expensive, and destructive to the paint surface, these *Guidelines* strive to keep its use to a minimum. Laboratory results can be reported either as mg/cm^2, like XRF readings, or as the percentage of lead by weight of the paint sample. These two units of measure are not interchangeable. Unless the weight of the paint sample is known, it is not possible to convert mg/cm^2 to percent by weight. These *Guidelines* recommend using laboratory results reported in mg/cm^2 if the surface area can be accurately measured and all paint within that area can be appropriately removed. Therefore, the area from which the paint-chip sample was removed should be measured as accurately as possible.

Two other methods of inspecting for lead in paint are available: chemical test kits and mobile laboratories. Currently, there are three basic chemical test kit technologies currently on the market. One type is based on the formation of black lead sulfide by the reaction of lead in paint with sodium sulfide. Another is based on the formation of a red or pink coloration caused by the reaction of lead in paint with sodium rhodizonate. The remaining type is a proprietary technology. There are several kits based on rhodizonate or sulfide and one that is proprietary at the time of this writing. The test kits differ in their testing protocols and sometimes in the exact formulation of the reagent. Test kits are destructive to the paint surface and provide less accurate classifications than do XRF readings. Test kits are of limited value for testing for lead in paint. Thus, test kits are not currently recommended for lead-based paint inspections. However, as chemical test kit technology improves, test kits may be recommended for use at some future date. Information on test kits or other new technologies for testing for lead in paint can be obtained from the National Lead Information Center Clearinghouse (1–800–424–LEAD).

Rapid laboratory analytical techniques used by mobile laboratories have recently been developed. These techniques are recommended only if recognized by NLLAP. A mobile laboratory is defined by EPA to be a transportable facility, such as a trailer or van, which can perform analytical testing under controlled environmental conditions. See Section VI of this chapter for further details regarding recognized laboratories.

III. XRF Radiation Safety Issues

Portable XRF instruments used for lead-based paint inspections contain radioactive isotopes that emit X rays and gamma radiation. Proper handling of these instruments is required to protect the instrument operator and any other persons in the immediate vicinity during XRF usage. The XRF instrument should be in the operator's possession at all times and the operator should not defeat or override the safety mechanisms of XRF equipment. All portable XRF instrument operators should be trained by the manufacturer of the instrument. The operators must be listed on valid licenses or permits from the appropriate Federal, State, and local regulatory bodies to operate the instrument because of radioactive materials contained within XRF instruments. Furthermore, the XRF instrument operator should be certified if the State in question has a certification program. Documentation of training, licensing, permitting, and certification should be provided by the operator to the user of the inspection services prior to initiation of any inspection activities.

The regulatory body responsible for oversight of radioactive materials contained in the portable XRF instruments is generally dependent on the type of material being handled. Some radioactive materials are federally regulated by the United States Nuclear Regulatory Commission (NRC) while others are regulated at the State level. States are generally categorized as "agreement" and "non-agreement" States. An "agreement" State is one that has an agreement with NRC to regulate specific types of radioactive materials that are generally used for medical or industrial applications. Most of the radioactive materials found in XRF instruments are regulated by "agreement" States. For "non-agreement" States, NRC retains this regulatory responsibility directly. However, most State agencies require, at a minimum, prior notification that a specific XRF instrument is to be used within the State. Specifics as to fees and other details regarding the use of a portable XRF instrument vary from State to State. Contractors supplying inspection services must hold up-to-date licenses or permits for handling the XRF instrument and must meet any applicable laws or notification requirements for the State.

Requirements for radiation dosimetry by the XRF instrument operator (the wearing of dosimeter badges to monitor exposures to radiation) are generally dictated by State regulations and vary from State to State. In some cases, for some isotopes, no radiation dosimetry is required. However, because the cost of dosimetry is low, it should be done, even when not required, for the following three reasons: (1) An operator of an XRF instrument has a right to know the level of radiation he/she is being exposed to during the performance of the job. (2) Long-term collection of radiation exposure information can aid both the operator (employee) and the employer. The employee benefits by knowing when to avoid a hazardous situation; the employer benefits by having an exposure record that can be used in deciding possible health claims. (3) The public also benefits by having exposure records available to them.

The safe operating, direct line-of-fire distance between an XRF instrument and a person during inspections is dependent on the radiation source type, radiation intensity, quantity of radioactive material, and the density of the materials in the direct line of fire. As the radiation source quantity and intensity increases, the required safe distance also increases. Placement of materials in the direct line of fire, such as a wall, reduces the required safe distance. According to NRC rules and regulations,[1] a radiation dose to an individual in any unrestricted area must not exceed 2 millirems per hour. One of the most energetic sources currently used in XRF instruments is a 40 millicurie Co^{57} (Cobalt-57) radiation source. Other radiation sources in current use for XRF testing of lead-based paint generally produce lower levels of radiation than this source. Therefore, calculation of a safe distance for this radiation source provides a safe guide for performance of XRF testing in an occupied dwelling. A 40 millicurie Co^{57} radiation source produces gamma radiation at 3.6 millirems per hour at an unshielded distance of 1 meter.[2] Using the inverse square distance law that governs radiation intensity (radiation intensity falls off at a rate of the reciprocal of the distance squared), a distance of approximately 10 feet would limit exposure to about 0.5 millirem per hour. Therefore, provided that the high-energy radiation intensity for a given XRF instrument is no higher than that given in this example, an XRF operator conducting inspections in a manner that avoids any direct-line-of-fire testing closer than 10 feet would be exposed to radiation well below the regulatory level.[3] XRF instruments with lower gamma radiation intensities can use a shorter safe distance provided that the potential exposure to an individual will not exceed 2 millirems per hour. The owner or landlord of the building being tested should seek to obtain cooperation of occupants in helping the inspection contractor achieve this safe XRF testing distance. Neighboring units should be unoccupied if XRF testing is being done on adjoining walls, ceilings, and flooring.

IV. Inspections in Single-Family Housing

The seven steps listed below should be followed:

- Inventory all painted building components, including those that are stained, shellacked, varnished, coated, or painted and covered with wallpaper.

- Select painted surfaces to be tested.
- Perform XRF testing (including the calibration check readings).
- Collect and analyze paint-chip samples for components that cannot be tested with XRF or that had inconclusive XRF results.
- Classify XRF and paint chips results.
- Evaluate the work and results to ensure the quality of the paint inspection before payment is made.
- Document all findings in a report.

A. Inventory and Selection of Painted Surfaces

An inventory of the painted surfaces in interior rooms, on exterior walls, and on surfaces in other exterior areas, such as fences, playground equipment, and garages, should be conducted. The “Single-Family Housing LBP Testing Data Sheet” (see forms at the end of this chapter) or a comparable form may be used for this purpose. An inventory of a house may be completed prior to any XRF testing or it may be done on a room-by-room basis during testing.

On Form 7.1, a *room equivalent* is an identifiable part of a residence, such as a room, a house exterior side, or an exterior area. Hallways, stairways, and exterior areas, such as porches, back yards, and each side of the house, are all examples of room equivalents. Closets or other adjoining areas to room equivalents should be designated room equivalents if large (for example, a walk-in closet) or if obviously dissimilar (for example, a different color) from the adjoining room equivalent. However, most closets are not room equivalents.

Each room equivalent is made up of *components*. Components can be located inside or outside the dwelling. For example, components in a bedroom could be the ceiling, floor, walls, a door and its casing, the window sash, and window casings. Table 7.1 displays examples of common components that should be tested (if present). This list is not intended to be all inclusive. Unlisted components that are coated with paint, varnish, shellac, stain, or other coating should also be tested. Some components may be grouped if painting histories are identical as described below.

The *substrate* is the material underneath the paint. Many substrates exist, but these *Guidelines* recommend classifying substrates into one of six substrate types: brick, concrete, drywall, metal, plaster, and wood. These substrate types are intended to include a broad range of materials. For example, the concrete substrate type includes poured concrete, precast concrete, and concrete block. If the true substrate is not one of the six types, the substrate type that most closely matches the true substrate should be selected. For substrates on top of substrates, such as plaster over concrete, the substrate directly beneath the painted surface should be used. For practical purposes, paint is almost always differentiated by *color*. Since more than one color may be observed when paint is peeling or the substrate is damaged, both “white” and “blue over green” would be acceptable color entries.

A *testing combination* is characterized by the room equivalent, component, substrate, and visible color of the paint. A completed inventory of the painted components in a room equivalent is a list of the testing combinations in that room equivalent. On the “Single-Family Housing LBP Testing Data Sheet,” the room equivalent should be recorded at the top of the form and all testing combinations found in that room equivalent should be listed. The first three columns of each row of the “Single-Family Housing LBP Testing Data Sheet” uniquely define each testing combination found in the room equivalent.

Table 7.2 provides five examples of different testing combinations. The first example is a wooden bedroom door that is painted brown. This is a testing combination because it is described by a room equivalent (bedroom), component (door), substrate (wood), and color

Table 7.1 Examples of Interior and Exterior Components

Commonly encountered interior painted components that should be tested include:

air conditioners	floors
balustrades	handrails
baseboards	jambs
bathroom vanities	newel posts
beams	other heating units
built-in cabinets	radiators
ceilings	railing caps
chair rails	shelf supports
columns	shelves
counter tops	stair stringers
crown molding	stair treads and risers
doorjambs and trim	stools and aprons
doors	walls
electrical fixtures	window sashes
fireplaces	

Exterior painted components that should be tested include:

air conditioners	handrails
balustrades	lattice work
bulkheads	mailboxes
ceilings	painted roofing
chimneys	railing caps
columns	rake boards
cornerboards	sashes
door trim	siding
doors	soffits
fascias	stair risers and treads
flashing	stair stringers
floors	window casings
gutters and downspouts joists	window sashes

Other exterior painted components include:

fences
lampposts
laundry line posts
painted curbing and signs
storage sheds
swingsets and other play equipment

Note: This list is not necessarily complete; other painted components should also be tested if encountered.

(brown). Testing combinations that are *known* to have been replaced after 1980 probably do not contain lead-based paint and need not be tested. If there is doubt about the age of the testing combination, the testing combination should be added to the inventory and tested.

When filling out the inventory portion of the "Single-Family Housing LBP Testing Data Sheet" form, similar components that are painted different colors should be listed separately. Thus, each line of the form will uniquely describe a testing combination. Examples are two walls of a room equivalent painted different colors or upper and lower walls separated by a chair rail painted different colors.

The *test location* is a specific area on a testing combination where XRF instruments will test for lead-based paint. For single-family housing, these *Guidelines* recommend XRF testing on *three locations per testing combination.* The selection of the test locations should be such that they are representative of the paint over the entire area of the testing combination. At each test location, all layers of paint should be included and the XRF probe faceplate should be able to lie flat against the surface of the test location. Locations should not be selected where the paint may be thickest or thinnest; for example, in corners or on the wall against a door casing where the paint may have been applied by brush *and* roller; where there are obvious depressions in the painted surface, where paint had obviously been scraped in the past, or where the paint is thin or worn; and areas over pipes and electrical outlets (wall stud detectors may be useful for detecting these problem locations). If acceptable locations cannot be found for XRF testing, a *single* paint-chip sample from a representative location on the testing combination that includes all paint layers and is also unobtrusive should be collected.

The three test locations for XRF testing should be spread out so that one test location is located on each third of the testing combination. To select three test locations, the testing combination should be divided into three segments of roughly equal size and then a test location selected on each segment as described above. The three selected locations should be far enough apart so that the placement of the XRF probe faceplate at one test location will not overlap any other test location.

Some testing combinations may be replicated (repeated) within a room equivalent. Examples are four walls or two door casings that are part of the same testing combination. In the examples, the walls have four replications while the door casings have two replications. If testing combinations are replicated, the selection of the test locations should be spread out on the replicates. For example, three of the walls should be selected to test. Test locations can

Table 7.2 Examples of Testing Combinations

Room Equivalent	Component	Substrate	Color
Bedroom	Door	Wood	Brown
Kitchen	Wall	Plaster	Green
Garage	Floor	Concrete	Red over black
West side of house	Siding	Wood	Yellow on blue
Exterior area playground	Swingset	Metal	Orange
Exterior area playground	Swingset	Metal	Green

be further spread out by selecting one location near the ceiling, the second centered on a wall, and the third near the floor.

On the “Single-Family Housing LBP Testing Data Sheet,” the test locations should be described with sufficient detail to permit another individual to find the approximate position of the test location. This can be accomplished by using the following numbering scheme: “wall 1” faces the front of the house on the address side and the other walls are numbered in clockwise fashion. For example, if four walls in a room comprise a testing combination, the test location might be identified as “wall 1 near ceiling, wall 2 near center, and wall 4 near floor.”

B. XRF Instrument Reading Time

Each XRF measurement will consist of one reading made on the painted surface of each test location. The recommended nominal open-shutter time (or nominal time) for an XRF reading depends on the specific XRF instrument. The *XRF Performance Characteristics Sheet* should be consulted to determine the nominal time recommended for a specific XRF instrument. A fairly typical nominal time is about 15 seconds for a new radioactive source.

The open-shutter time needs to be increased as the source ages to ensure the delivery of a constant amount of radiation to the painted surface. Several available XRF instruments automatically adjust for the age of the source. For instruments that do not adjust, the inspector technician needs to set the open-shutter time using the following formula:

$$\text{Open-Shutter Time} = 2^{(\text{Age/Half-Life})} \text{ x Nominal Time}$$

where *Age* is the age of the source, *Half-Life* is the time it will take for the radioactive material to decay to one-half its initial level of activity, and *Nominal Time* is the recommended nominal time in seconds that is obtained from the *XRF Performance Characteristics Sheet*. If the age of the source is equal to its half-life, the open-shutter time should be doubled. For example, if the recommended nominal time is 15 seconds, the open-shutter time would be doubled to 30 seconds.

C. XRF Calibration Check Readings

In addition to the manufacturer's recommended warmup and quality control procedures, the XRF instrument operator should take the quality control readings recommended by these *Guidelines*, unless the manufacturer's instructions already provide for the readings described below. The quality control readings will be used to help monitor the performance of the XRF instrument and will be referred to as the calibration check readings. Two sets of XRF calibration check readings are recommended for each XRF instrument in each house. A set of three nominal-time XRF calibration check readings should be taken before the inspection begins and after the inspection has been completed in the house, or every 4 hours, whichever occurs first. At the beginning of the day, the first set of readings will be referred to as the initial calibration check readings. Subsequent calibration check readings will be referred to as the second set, third set, etc. If the inspection does not require 4 hours, the second set of calibration check readings would be done at the conclusion of the inspection in the house.

The XRF calibration check readings recommended by these *Guidelines* are taken on the red 1.02 mg/cm^2 Standard Reference Material (SRM) paint film, developed by the National Institute of Standards and Technology (NIST). These films can be obtained by calling (301) 975–6776 and referencing SRM #2579. The cost as of January 1, 1995, was approximately $300. Calibration check readings should be taken through the red 1.02 mg/cm^2 SRM paint film when the film itself is at least 12 inches away from any source of lead. For example, the red NIST SRM film should not be placed on a tool box or suitcase or on a surface coated with lead-based paint to take calibration check readings. Instead, the red NIST SRM film should be attached to a wooden board measuring about 6 inches long by 4 inches wide by 1 inch thick or attached directly to the XRF probe. Readings can then be taken while standing further than a foot from the wall. Alternatively, the red NIST SRM film can be placed on top of a 12 inch piece of styrofoam or some other lead-free material as recommended by the manufacturer before taking readings.

Each time calibration check readings are made, three nominal-time readings should be taken on the red NIST (1.02 mg/cm^2) SRM film and the results recorded on the "Calibration Check Test Results" form (Form 7.2) or a comparable form. The average of the three calibration check readings should be computed and recorded.

Large differences of calibration check reading averages from 1.02 mg/cm^2 may alert the inspector technician to problems in the instrument's performance. The calibration check reading averages should not differ from 1.02 mg/cm^2 by more than the calibration check tolerance specified in the *XRF Performance Characteristics Sheet* for the specific instrument used. This comparison will be referred to as the calibration check test.

If the observed calibration check average minus 1.02 is greater than the calibration check tolerance, the instructions provided by the manufacturer should be followed in order to bring the instrument back into control before any more XRF testing is done. All readings taken by the suspended instrument since the last successful calibration check test should be repeated. If a backup XRF instrument is used as a replacement, the backup instrument must successfully pass the initial calibration check test before retesting the affected test locations.

D. Number of Readings on Each Testing Combination

For inspections of single-family housing, three XRF readings should be taken on each testing combination and the average of the three readings computed (multifamily housing procedures are different and are described later in this chapter). These averages will be referred to as XRF results. XRF results may need to be corrected for substrate interference; if necessary, this will be specified in the *XRF Performance Characteristics Sheet*. XRF results, if corrected for substrate interference or not, are used to classify lead in the paint using the methodology provided later in this chapter.

Inspections should be conducted according to the manufacturer's instructions on XRF testing for lead-based paint in a house (including the manufacturer-recommended quality control readings). If the manufacturer calls for the deletion of readings at specific times, only readings taken at those specific times should be deleted. Readings should not be deleted based on any criteria other than what is specified by the manufacturer's instructions. For example, some manufacturers instruct operators to discard the first XRF reading if a substrate change occurs. If this instruction is applicable, only the *first* reading should be discarded after a substrate change. Also, any manufacturer-recommended time for readings may be used only if equal to or greater than the nominal-time reading specified in the *XRF Performance Characteristics Sheet*.

E. Substrate Correction

Sometimes XRF readings are subject to systematic biases (both high and low) caused by interference from the substrate material underlying the paint. The magnitude and direction (positive or negative) of bias depends on the substrate, the specific XRF instrument being used, and possibly factors such as temperature and humidity. Some XRF instruments do not need to have their readings corrected for substrate bias. Other instruments may only need to apply substrate correction procedures on specific substrates or when XRF results are below a certain value. The *XRF Performance Characteristics Sheet* should be consulted to determine the requirements for each specific instrument. The *XRF Performance Characteristics Sheet* will state which substrates require correction and which do not.

If it is necessary to correct XRF readings for single-family housing, these *Guidelines* recommend correcting the average of the three XRF readings (or XRF results) taken on a testing combination instead of correcting each reading individually. For those XRF instruments where results need to be corrected for substrate bias, a description of the methodology follows.

XRF results are corrected for substrate bias by subtracting a correction value determined separately in each house for each type of substrate. The correction value (formerly called "Substrate Equivalent Lead" or "SEL") is an average of XRF readings taken from test locations that have been scraped clean of their paint covering. A criterion for selecting these test locations is that their initial XRF results are less than 2.5 mg/cm^2. If test locations with XRF results equal to or greater than 2.5 mg/cm^2 were selected, the outcome might "overcorrect" XRF results. Therefore, only test locations with initial XRF results less than 2.5 mg/cm^2 should be chosen. If all initial readings on a substrate type are above 2.5 mg/cm^2, the locations with the lowest initial reading should be chosen. This will help ensure that XRF readings taken from nonrepresentative portions of substrates and other underlying materials, such as hidden nails and pipes, are not used to compute the substrate correction. It is important to note that some XRF results may not need to be corrected for substrate bias depending on the specific instruments used and the specifications in the *XRF Performance Characteristics Sheet*. The correction values should be computed as follows:

- After all XRF testing in a house has been completed but before the final calibration check test has been conducted, compute the XRF results (that is, the average of the three XRF readings for each testing combination).

- For each substrate type tested, create a list of all testing combinations with XRF results (reading averages) less than 2.5 mg/cm,^{2} if substrate correction is needed at all.

- Randomly select two testing combinations from each list.

- On each selected testing combination, choose one location from which to remove the paint. The chosen location should be unobtrusive and coated with paint that is representative of the paint on the testing combination. Note that any testing combination location from which a paint-chip sample has been removed for laboratory analysis may also be used to take substrate correction readings, but only if the samples XRF result was less than 2.5 mg/cm^2 and provided the XRF probe faceplate can properly cover the area.

- Carefully remove the paint from each selected location using the methodology described later in this chapter for collecting paint-chip samples (ASTM ES 28–94). The size of the area from which paint is to be taken depends on the size of the analytical area on the XRF probe faceplate. The bare area on the substrate should be at least as large as the analytical area on the XRF probe faceplate. Areas from which paint has been removed for substrate correction readings may also be used for laboratory analysis if the paint has been removed according to the protocol for paint-chip sampling.

- Using the same XRF instrument, take three readings on the first *bare* substrate area. Record the substrate and XRF readings on the "Substrate Correction Values" form (Form 7.3) or a comparable form. Repeat this procedure for the second *bare* substrate area and record the three readings on the same form. A variant to this step is to first cover the bare area with an NIST SRM film prior to taking the readings. The need for this variation will be specified in the *XRF Performance Characteristics Sheet* for affected XRF instruments and instructions will be provided explaining how to compute the correction value when this variation is used.

- Compute the correction value for each necessary substrate type in the house by computing the average of all six readings as shown below and recording the results on the "Substrate Correction Values" form. The formula given below is to be used to compute the substrate bias correction value for XRF readings taken on bare substrate without covering it with an NIST SRM film. The formula to use when it is necessary to place an NIST SRM film over the bare substrate is different and depends on which NIST SRM film and XRF instrument are used. The *XRF Performance Characteristics Sheet* will specify when this correction is necessary and will provide the appropriate formula for computing the correction value.

For each substrate type:

$$\left.\begin{matrix}\text{Correction}\\ \text{Value}\end{matrix}\right\} = \frac{1^{st} + 2^{nd} + 3^{rd} + 4^{th} + 5^{th} + 6^{th}\ \text{Reading}}{6}$$

- Transfer the recorded correction values to the "Single-Family Housing LBP Testing Data Sheet" (Form 7.1) for each corresponding substrate. Correct XRF readings for substrate interference by subtracting the correction value from each average of three XRF readings.

1. Example

Suppose that a house has 50 testing combinations composed of wood and the *XRF Performance Characteristics Sheet* states that it is necessary to compute a correction value for XRF readings taken on all wood testing combinations in the house. Randomly select two test locations from the list of testing combinations that had uncorrected XRF results (reading averages) of less than 2.5 mg/cm^2. Remove the paint from these two test locations and take three nominal-time XRF readings on the bare substrate at each location. Suppose the results of the six XRF readings in mg/cm^2 at the two random locations are:

Selected Location	XRF Reading		
	First	Second	Third
First	1.32	0.91	1.14
Second	1.21	1.03	1.43

Then the correction value is:

$$\left.\begin{matrix}\text{Correction}\\ \text{Value}\end{matrix}\right\} = \frac{1.32 + 0.91 + 1.14 + 1.21 + 1.03 + 1.43}{6} = 1.17$$

In this same house, suppose that three different wood testing combinations were inspected for lead-based paint, resulting in the following XRF results (reading averages): 1.63 mg/cm^2, 3.19 mg/cm^2, and 1.14 mg/cm^2. Correcting these three XRF results for substrate bias produces the results shown below.

$$\left.\begin{matrix}\text{First Corrected}\\ \text{Result}\end{matrix}\right\} = 1.63 - 1.17 = 0.46$$

$$\left.\begin{matrix}\text{Second Corrected}\\ \text{Result}\end{matrix}\right\} = 3.19 - 1.17 = 2.02$$

$$\left.\begin{matrix}\text{Third Corrected}\\ \text{Result}\end{matrix}\right\} = 1.14 - 1.17 = -0.03$$

The third corrected result shown above is an example of how random error found in XRF measurements can cause the corrected result to be less than zero. (Random measurement error is present whenever any quantitative measurements are taken.) Note that correction values can be either positive or negative.

As another example, suppose an XRF result (reading average) is 1.24 mg/cm^2 and the correction value is negative 0.41 mg/cm^2. The corrected measurement would be:

$$\left.\begin{matrix}\text{Corrected}\\ \text{Result}\end{matrix}\right\} = 1.24 - (-0.41) = 1.24 + 0.41 = 1.65$$

F. Classification of XRF Results

For purposes of this chapter, the term lead-based paint means paint or other surface coatings that contain lead greater than or equal to 1.0 mg/cm^2 or 0.5 percent by weight. This will be referred to as the "HUD standard" for lead in paint. These *Guidelines* recommend classifying XRF results relative to the 1.0 mg/cm^2 HUD standard whenever possible.

XRF results are classified as positive, negative, or inconclusive. A *positive* classification indicates that lead is present on the testing combination at or above the HUD standard. A *negative* classification indicates that lead is not present on the testing combination at or above the HUD standard. An *inconclusive* classification indicates that the XRF test result cannot determine with reasonable certainty whether lead is present on the testing combination at or above the HUD standard. It is important to note that positive, negative, and inconclusive results apply not only to the actual testing combination, but also to any repetitions of the testing combination in the room equivalent that were not tested. For example, suppose that four walls comprise a testing combination and that XRF readings were taken on test locations from three of the walls. The resulting classification would be based on the XRF result from the three tested walls but the classification also applies to the untested fourth wall.

XRF results are classified as positive if equal to a predetermined upper limit or greater. Similarly, XRF results are classified as negative if equal to a predetermined lower limit or less; otherwise, the results are classified as inconclusive. In other words, XRF results that fall within the inconclusive range (that is, less than the predetermined upper limit and greater than the predetermined lower limit) are classified as inconclusive. Different XRF instruments have different inconclusive ranges. The *XRF Performance Characteristics Sheet* provides the limits that define the inconclusive range for those XRF instruments commercially available for use. Depending on the specific XRF instrument, the inconclusive range may or may not be substrate specific. Also, for some XRF instruments, the upper and lower limits may be equal. In this case, XRF results would be classified as either positive or negative.

The inconclusive range is computed for each specific XRF instrument, such that 95 percent of true negative results are classified as negative and 95 percent of true positive results are classified as positive. These classification results are computed for XRF instrument usage over a large number of housing units and may not necessarily be the classification obtained in a single house or unit or surface. In general, XRF instruments will best classify paint in those units where most lead levels are either low (that is, much less than 1.0 mg/cm^2) or high (2.5 mg/cm^2 or greater). In unusual cases where there is a preponderance of lead levels close to the 1.0 mg/cm^2 HUD standard, classification accuracy in the particular house or unit will be lower than 95 percent.

The XRF classifications are determined from either the three XRF readings taken on a testing combination or the same three XRF readings corrected for substrate bias using the methodology given above. The substrate on which readings are taken affects how a specific XRF instrument measures lead in its paint. Readings from some XRF instruments may require correction only on specific substrates while other instruments may not need any readings corrected. For specific XRF instruments, the *XRF Performance Characteristics Sheet* specifies on which substrates readings need to be corrected for substrate bias and the magnitude of readings requiring substrate correction.

Provided below are the rules for classifying XRF results relative to the HUD standard. For single-family housing, these rules are applied to XRF results (reading averages) using the inconclusive range specified in the *XRF Performance Characteristics Sheet* for specific XRF instruments. The rules are the same regardless of whether or not readings are corrected for substrate bias. For discussion purposes, examples in which 1.500 mg/cm^2 is the upper limit and 0.500 mg/cm^2 is the lower limit are provided. The values selected for these limits are for illustrative purposes only. The inconclusive range for a specific XRF instrument as specified in the *XRF Performance Characteristics Sheet* may be different.

Positive:

XRF results are equal to the upper limit or greater. For example, if the upper limit is 1.500 mg/cm,^{2} then a result of 2.000 mg/cm^2 would be classified as positive.

Negative:

XRF results are equal to the lower limit or less. For example, if the lower limit is 0.500 mg/cm^2, then results equal to 0.500 mg/cm^2 or 0.200 mg/cm^2 would both be classified as negative. Note that lead may still be present and hazardous dust may be generated during modernization, renovation, remodeling, maintenance, or other disturbances of painted surfaces.

Inconclusive Range:

XRF results are less than the upper limit and greater than the lower limit. For example, if the inconclusive range has an upper limit equal to 1.500 mg/cm^2 and a lower limit equal to 0.500 mg/cm^2, then a result of 1.300 mg/cm^2 would be classified as inconclusive.

G. Paint-Chip Collection and Laboratory Analysis

For inconclusive XRF results and areas that cannot be tested using an XRF instrument, a paint-chip sample should be removed using the protocol outlined in this chapter and sent to a laboratory recognized by the NLLAP for analysis. The inconclusive range specified for a particular XRF instrument will affect how many of its results are classified as inconclusive, and in turn, how many paint-chip samples require laboratory analysis. XRF instruments with wider inconclusive ranges are more likely to have a greater number of results that are classified as inconclusive than are XRF instruments with narrower inconclusive ranges. Therefore, the choice of which XRF instrument to use for an inspection will have an impact on how many paint-chip samples require laboratory analysis. The different inconclusive ranges specified for each XRF instrument can be obtained by comparing the *XRF Performance Characteristics Sheets* provided for those XRF instruments commercially available for use.

The paint-chip sample should be taken from a 4-square-inch area that is representative of the paint on the testing combination and is unobtrusive. Areas from which paint-chip samples are collected should be repaired. This area may be, for example, a 2- by 2-inch square or a 1- by 4-inch rectangle. Regardless of its shape, the dimensions of the surface area must be accurately measured so that laboratory results can be reported in mg/cm^2. Results should only be reported as percent by weight if the dimensions of the surface area cannot be accurately measured or if all paint within the sampled area cannot be appropriately removed. In these cases, lead should not be reported in mg/cm^2.

The 4-square-inch area (which is a larger area than recommended in the ASTM ES 28–94 document) practically guarantees that a sufficient amount of paint will be collected for laboratory analysis. As a result, samples will sometimes weigh more than is required for some laboratory analysis methods. In such cases, homogenization and subsampling in the laboratory will be necessary prior to analysis. Refer to Section VI of this chapter for additional information.

All paint inspections may be carried out using paint-chip sampling and laboratory analysis at the option of the purchaser of the inspection services. However, this option is not recommended because it is time consuming, costly, and requires extensive repairs. Laboratory results of 1.0 mg/cm^2 or greater (or 0.5 percent or greater) are to be considered positive. All other results are negative. There is no inconclusive range for laboratory measurements.

H. Evaluation of the Inspection by the Owner

The person responsible for purchasing the inspection services (homeowner, property owner, housing authority, prospective buyer, etc.) should evaluate the work before payment is made using one or more of the following options. It is recommended that the first option be used whenever possible. The inspection contract should clearly state that payment will be made only upon passing the customer's evaluation.

- Observe the XRF testing and be present for much of the inspection. Make sure the inspector technician inventories and tests all painted, varnished, shellacked, or stained surfaces and records the XRF readings correctly.

- Carry out unannounced visits to observe the inspection process. The number of unannounced visits will depend on the results of prior visits. When observing ongoing XRF testing, review the test results for the room equivalent currently being tested and for the previously inspected room equivalent. Even if the first visit is fully satisfactory, additional visits should occasionally be implemented. The inspection contract should outline the financial penalties if an inspector technician fails an unannounced visit.

- Require the inspector technician to provide results on completed data forms on a daily basis. Visually review results to ensure that they are properly recorded for all surfaces requiring XRF testing. If a substantial number of surfaces have been overlooked or incorrectly recorded, the inspection process should be halted and should be considered deficient.

- Require retesting of 10 testing combinations. Select the 10 testing combinations for retesting at random from the already compiled list in the "Single-Family Housing LBP Testing Data Sheet" (see forms at the end of this chapter). Observe the inspector technician during the retest and, if possible, request that the same XRF instrument be used as was used to take the original readings. The retesting of the 10 testing combinations should be done using the same procedures as for inspections of single-family housing described above. That is, the inspector technician should take 3 XRF readings at each of the 10 testing combinations for a total of 30 repeat XRF readings. Then the 10 repeat XRF results* should be compared to the 10 XRF results that were previously made on the same testing combinations; the repeat readings or the original readings should not be corrected for substrate bias. The average of the 10 repeat XRF results should not differ from the 10 original XRF results by more than the retest tolerance limit computed from information provided in the *XRF Performance Characteristics Sheet.* If this retest tolerance limit is exceeded, the procedure should be repeated using 10 different testing combinations. If the retest tolerance limit is exceeded again, the inspector technician should be required to retest the entire house.

A related issue pertains to the laboratory work. The purchaser of inspection services may choose to contract for any needed laboratory work independent from the XRF testing services. If the laboratory was contracted inde pendent of the XRF testing firm, the customer may choose to complete the remaining portion of the data collection forms instead of the inspector technician.

I. Documentation in Single-Family Housing

Two possible methods of data documentation are recommended. One method for recording XRF readings is on handwritten forms, such as

*For inspecting single-family housing, an XRF result is the average of the three XRF readings taken on a testing combination. For inspecting multifamily housing, an XRF result is a single XRF reading taken on a testing combination (as described later in this chapter).

the complete set of forms provided for inspecting single-family housing at the end of this chapter (or comparable forms). Handwritten data collection can result in transcription errors; therefore, handwritten forms should be examined for missing data and copying errors. The other method of data collection is electronic storage. This method is recommended only if sufficient data are recorded to allow another person to find the test location that corresponds to each XRF reading. Caution should be exercised when using electronic data collection due to potential loss of data. These *Guidelines* recommend examining on a daily basis "hard-copy" listings of the electronically stored data for extraneous symbols or missing data, including missing test location identification.

A summary report should be provided that answers two questions: (1) Is there lead-based paint in the house? (2) If lead-based paint is present, where is it located? The summary report should also include the house address where the inspection was performed, the date(s) of the inspection, the name of the inspector and any appropriate license or certification number, and the starting and ending times for each day when XRF testing was done. Detailed documentation of the XRF testing should also be provided in the full report, including the raw data. The single-family housing forms provided at the end of this chapter or comparable forms completed by the inspector technician, would serve this purpose.

J. Example of Single-Family Housing Inspection

First, the inspector technician completed the "Single-Family Housing LBP Testing Data Sheet," recording "kitchen" as the room equivalent and listing "wood" as the first substrate. The completed inventory of testing combinations in the kitchen indicated the presence of wood, plaster, and metal substrates. Drywall, brick, and concrete substrates were not present in the kitchen. Descriptions of all testing combinations in the kitchen were recorded in the column titled "Test Location." Figure 7.1 shows the completed inventory for all testing combinations in the kitchen.

Prior to any XRF testing, the inspector technician performed the manufacturer's recommended warmup and quality control procedures. After successfully completing the manufacturer's quality control procedure, the inspector technician took a set of three calibration check readings on the red NIST SRM film placed over 12 inches of styrofoam. Results of the first calibration check readings were recorded on the "Calibration Check Test Results" form (Figure 7.2). The inspector technician then averaged the three readings and computed the difference between this average and 1.02 mg/cm^2. Since the difference (0.054 mg/cm^2) did not exceed the 1.0 mg/cm^2 calibration check tolerance obtained from the *XRF Performance Characteristics Sheet* (Figure 7.3), there was no indication that the instrument was out of control; thus, XRF testing could begin.

The inspector technician recorded the results from the XRF testing in the kitchen on the "Single-Family Housing LBP Testing Data Sheet." The inspector technician was only able to complete this form through the "XRF Reading" column (Figure 7.4). The remainder of the form was completed only after all test locations in the house were inspected and correction values for substrate bias were computed. The inspector technician then moved on to inspect the next room equivalent.

The next room equivalents inspected were two bedrooms and a bathroom. Three substrates were found in these room equivalents: wood, drywall, and plaster. XRF testing for lead-based paint was done using the same methodology as in the kitchen.

When 4 hours had elapsed since the initial calibration check readings were taken, the inspector technician took another set of three calibration check readings and recorded the results on the "Calibration Check Test Results" form (Figure 7.5). (Many inspections will probably not require 4 hours; therefore, the second

Single-Family Housing LBP Testing Data Sheet

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Address/Unit No. 1994 Mapleton Ave, Newtown, Maryland   Date March 15, 1995

Room Equivalent Kitchen

XRF Serial No. AB-2283   Inspector Signature Joseph Smith

Substrate	Component	Color	Test Locations	XRF Reading	Correction Value	Result	Classification (pos, neg, Inc)	Laboratory Result	UNIT?	Final Classification
Wood	Baseboard	White	Wall 3, Center						mg/cm² %	
			Wall 3, Left							
			Wall 3, Right, below outlet							
Plaster	Wall	White	Wall 3, High center						mg/cm² %	
			Wall 3, Low center							
			Wall 3, Mid right, just to left of outlet							
Wood	Door	Brown	Wall 2, Top center						mg/cm² %	
			Wall 2, Lower left quadrant							
			Wall 2, Center							
Wood	Window Casing	Yellow	Wall 2, Left window, top center						mg/cm² %	
			Wall 2, Left window, right center							
			Wall 2, Left window, bottom of left side							
Wood	Window Casing	Green	Wall 1, Top of right side						mg/cm² %	
			Wall 1, Center of left side							
			Wall 1, Bottom of right side							
Metal	Heating Duct	White	Wall 1, Right side						mg/cm² %	
			Wall 1, Center							
			Wall 1, Left side							
Plaster	Closet Wall	Green	Wall 1, Left of door, low						mg/cm² %	
			Wall 1, Above door							
			Wall 1, Right of door, center							
Wood	Cabinet	Brown	Wall 1, Left cabinet door						mg/cm² %	
			Wall 1, Right cabinet door							
			Wall 1, Left side of cabinet							
Metal	Door Casing	Blue	Wall 2, Above door						mg/cm² %	
			Wall 2, Left side, low							
			Wall 2, Right side, mid							

Form 7.1

Figure 7.1 Single-Family Housing LBP Testing Example: "Single-Family Housing LBP Testing Data Sheet" testing combination inventory of the kitchen.

Calibration Check Test Results

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Address/Unit No. 1994 Mapleton Avenue

Newtown, Maryland

Device XYZ Company Inc. XRF I

Date March 15, 1995 XRF Serial No. AB-2233

Contractor ACME Pb Testing Inc.

Inspector Joe Smith

Inspector Signature Joseph Smith

Calibration Check Tolerance Used 1.0 mg/cm²

First Calibration Check

Red NIST SRM 1.02 mg/cm²			First Average	Difference Between First Average and 1.02 mg/cm²*
First Reading	Second Reading	Third Reading		
1.162	0.992	1.068	1.074	0.054

Second Calibration Check

Red NIST SRM 1.02 mg/cm²			Second Average	Difference Between Second Average and 1.02 mg/cm²*
First Reading	Second Reading	Third Reading		

Third Calibration Check *(If required)*

Red NIST SRM 1.02 mg/cm²			Third Average	Difference Between Third Average and 1.02 mg/cm²*
First Reading	Second Reading	Third Reading		

Fourth Calibration Check *(If required)*

Red NIST SRM 1.02 mg/cm²			Fourth Average	Difference Between Fourth Average and 1.02 mg/cm²*
First Reading	Second Reading	Third Reading		

* If the difference of the Calibration Check Average from the red NIST SRM 1.02 mg/cm² film value is greater than the specified Calibration Check Tolerance for this device, consult the manufacturer's recommendations to bring the instrument back into control. Retest all testing combinations tested since the last successful calibration check test.

Form 7.2

Figure 7.2 Single-Family LBP Testing Example: "Calibration Check Test Results" form completed for the initial calibration check readings.

EXAMPLE OF AN XRF PERFORMANCE CHARACTERISTICS SHEET

EFFECTIVE DATE: *3/01/95*

MANUFACTURER AND MODEL:

Make: *XYZ Company, Inc.*
Model: *XRF I*
Note: This Sheet supersedes all previous Sheets for the make and model of XRF instrument shown above.

EVALUATION DATA SOURCE AND DATE:

Performance parameters shown in this Sheet are calculated from evaluation data collected during:
EPA/HUD field evaluation study, report dated 2/28/95

OPERATION PARAMETERS:

Performance parameters shown in this Sheet are applicable only when operating the above indicated XRF instrument under the conditions used during the evaluation testing. These operating parameters include:

- Manufacturer recommended warm-up and quality control procedures
- Readings for determining the substrate correction values need to be taken on bare substrates
- Use the Multifamily Decision Flowchart for determining the presence of lead on a component type
- Nominal 15-second readings

FOR XRF RESULTS BELOW 4.0 mg/cm², SUBSTRATE CORRECTION NEEDED ON:

Brick, Concrete, Drywall, Metal, Plaster, and Wood

SUBSTRATE CORRECTION NOT NEEDED ON:

None

ITEM	DESCRIPTION	VALUES
Inconclusive Range Limits (after substrate correction)	Readings corrected for substrate bias on all substrates	Brick = 0.06 to 1.05 Concrete = 0.76 to 1.28 Drywall = 0.18 to 1.14 Metal = 0.18 to 1.52 Plaster = 0.34 to 1.11 Wood = 0.26 to 1.17
Calibration Check Tolerance	Calibration Check Tolerance limits for this instrument	± 1.0 mg/cm²
Bias* (after substrate correction)	Measured at 0.0 mg/cm²	-0.78 mg/cm² for brick -0.64 mg/cm² for concrete -0.43 mg/cm² for drywall 0.02 mg/cm² for metal 0.62 mg/cm² for plaster -0.13 mg/cm² for wood
	Measured at 1.0 mg/cm²	-1.00 mg/cm² for brick -0.46 mg/cm² for concrete -0.43 mg/cm² for drywall 0.09 mg/cm² for metal -0.62 mg/cm² for plaster 0.06 mg/cm² for wood
Precision* (after substrate correction)	Measured at 0.0 mg/cm²	0.79 mg/cm² for brick 0.86 mg/cm² for concrete 0.62 mg/cm² for drywall 0.33 mg/cm² for metal 0.74 mg/cm² for plaster 0.45 mg/cm² for wood
	Measured at 1.0 mg/cm²	0.80 mg/cm² for brick 0.98 mg/cm² for concrete 0.46 mg/cm² for drywall 0.48 mg/cm² for metal 0.82 mg/cm² for plaster 0.53 mg/cm² for wood

*Do not use these bias or precision data to correct for substrate effects on a specific surface. Actual bias must be determined on the site (see HUD Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing).

Figure 7.3 Example of an XRF Performance Characteristics Sheet.

Single-Family Housing LBP Testing Data Sheet

Page 1 of 5

Address/Unit No. 1994 Mapleton Ave, Newtown, Maryland

Date March 15, 1995

Room Equivalent Kitchen

XRF Serial No. AB-2233

Inspector Signature Joseph Smith

Substrate	Component	Color	Test Locations	XRF Reading	Correction Value	Result	Classification (pos, neg, inc)	Laboratory Result	UNIT?	Final Classification
Wood	Baseboard	White	Wall 3, Center	0.952					mg/cm²	
			Wall 3, Left	1.106					%	
			Wall 3, Right, below outlet	1.442						
Plaster	Wall	White	Wall 3, High center	0.661					mg/cm²	
			Wall 3, Low center	0.598					%	
			Wall 3, Mid right, just to left of outlet	0.535						
Wood	Door	Brown	Wall 2, Top center	1.039					mg/cm²	
			Wall 2, Lower left quadrant	1.101					%	
			Wall 2, Center	1.277						
Wood	Window Casing	Yellow	Wall 2, Left window, top center	2.615					mg/cm²	
			Wall 2, Left window, right center	2.110					%	
			Wall 2, Left window, bottom of left side	1.468						
Wood	Window Casing	Green	Wall 1, Top of right side	0.922					mg/cm²	
			Wall 1, Center of left side	0.559					%	
			Wall 1, Bottom of right side	0.769						
Metal	Heating Duct	White	Wall 1, Right side	1.996					mg/cm²	
			Wall 1, Center	2.917					%	
			Wall 1, Left side	2.446						
Plaster	Closet Wall	Green	Wall 1, Left of door, low	0.241					mg/cm²	
			Wall 1, Above door	0.276					%	
			Wall 1, Right of door, center	0.176						
Wood	Cabinet	Brown	Wall 1, Left cabinet door	0.234					mg/cm²	
			Wall 1, Right cabinet door	0.218					%	
			Wall 1, Left side of cabinet	0.223						
Metal	Door Casing	Blue	Wall 2, Above door	0.359					mg/cm²	
			Wall 2, Left side, low	0.665					%	
			Wall 2, Right side, mid	0.552						

Form 7.1

Figure 7.4 Single-Family Housing LBP Testing Example: "Single-Family Housing LBP Testing Data Sheet" completed through XRF reading.

Calibration Check Test Results

Page 3 of 5

Address/Unit No. 1994 Mapleton Avenue

Newtown Maryland

Device XYZ Company, Inc. XRF I

Date March 15, 1995 XRF Serial No. AB-2233

Contractor ACME Pb Testing Inc.

Inspector Joe Smith

Inspector Signature Joseph Smith

Calibration Check Tolerance Used 1.0 mg/cm²

First Calibration Check

Red NIST SRM 1.02 mg/cm²			First Average	Difference Between First Average and 1.02 mg/cm²*
First Reading	Second Reading	Third Reading		
1.162	0.992	1.068	1.074	0.054

Second Calibration Check

Red NIST SRM 1.02 mg/cm²			Second Average	Difference Between Second Average and 1.02 mg/cm²*
First Reading	Second Reading	Third Reading		
2.450	2.216	2.099	2.255	1.235

Third Calibration Check *(if required)*

Red NIST SRM 1.02 mg/cm²			Third Average	Difference Between Third Average and 1.02 mg/cm²*
First Reading	Second Reading	Third Reading		

Fourth Calibration Check *(if required)*

Red NIST SRM 1.02 mg/cm²			Fourth Average	Difference Between Fourth Average and 1.02 mg/cm²*
First Reading	Second Reading	Third Reading		

* If the difference of the Calibration Check Average from the red NIST SRM 1.02 mg/cm² film value is greater than the specified Calibration Check Tolerance for this device, consult the manufacturer's recommendations to bring the instrument back into control. Retest all testing combinations tested since the last successful Calibration Check test.

Form 7.2

Figure 7.5 Single-Family LBP Testing Example: "Calibration Check Test Results" form completed through the second set of calibration check readings.

calibration check test would be done at the conclusion of the inspection.) After computing the difference between the second calibration check average and 1.02 mg/cm^2, the inspector technician found that the difference (1.235 mg/cm^2) exceeded the 1.0 mg/cm^2 calibration check tolerance. The inspector technician then clearly marked “XRF out of control” on the data sheets for those room equivalents that had been inspected since the last successful calibration check test and consulted the manufacturer’s recommendations to bring the instrument back into control. The instrument could not be brought back into control so the inspector technician began using a backup instrument. First, the inspector technician performed the manufacturer’s recommended warmup and quality control procedures using the backup XRF instrument. Second, the inspector technician took three calibration check readings with the backup instrument and recorded the results on a new “Calibration Check Test Results” form. The results of the calibration check test demonstrated that the backup instrument was in control. The inspector technician proceeded to reinspect the room equivalents that were checked with the first instrument. All other room equivalents were inspected using the backup instrument.

Next, the inspector technician prepared to take readings for use in the substrate correction computations, since substrate correction was required for all results below 4.0 mg/cm^2 as specified in the *XRF Performance Characteristics Sheet* for the XRF instrument in use. The inspector technician randomly selected two testing combinations of each substrate where initial readings were less than 2.5 mg/cm^2, removed the paint from an area on each selected testing combination, took three readings on the bare substrate as specified in the *XRF Performance Characteristics Sheet*, and recorded the readings on the “Substrate Correction Values” form (Figure 7.6). The inspector technician computed the correction values for each substrate by averaging the six readings from the two test locations and recorded the information in the “Correction Values” row. The correction values were then transferred to the “Single-Family Housing LBP Testing Data Sheet” for each corresponding substrate.

After the inspector technician had finished taking the readings to be used for computing the substrate correction values, another set of three calibration check readings were taken. The inspector technician recorded the results on the “Calibration Check Test Results” form for readings taken by the backup XRF instrument (Figure 7.7). Since the second (and final) calibration check average did not exceed the 1.0 mg/cm^2 calibration check tolerance, XRF testing in the house was completed.

Corrected reading averages were calculated by subtracting the correction value from each XRF result less than 4.0 mg/cm^2. Based on these corrected averages, there were 3 positive results, 10 inconclusive results, and 3 negative results. The 10 inconclusive results required paint-chip sampling with laboratory confirmation, which resulted in 5 positive and 5 negative results (Figures 7.8 and 7.9). The final summary report also included the address of the house that was inspected, the date(s) of inspection, and the starting and ending times for each day of the inspection (Figure 7.10).

V. Inspections in Multifamily Housing

This section presents the paint inspection protocol for multifamily housing, with emphasis on the differences between single-family and multifamily housing paint inspections. For purposes of this chapter only, multifamily housing is defined as any group of 21 or more units that are similar in construction from unit to unit. Developments with 20 or fewer units should be treated as single-family housing (that is, all units should be tested and the classification rules for single-family housing apply).

Use of the multifamily protocol is less time-consuming and more cost effective than the inspection of all units in a multifamily housing development using the single-family method.

Substrate Correction Values

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Address/Unit No. 1994 Mapleton Avenue

Newtown, Maryland

Date March 15, 1995 XRF Serial No. 88-2295

Inspector Signature Joseph Smith

Use this form when the *XRF Performance Characteristics Sheet* indicates that correction for substrate bias is needed.

Substrate			Brick	Concrete	Drywall	Metal	Plaster	Wood
Location	1	First Reading	0.097	0.109	0.096	0.091	0.088	0.127
		Second Reading	0.121	0.105	0.108	0.073	0.095	0.119
		Third Reading	0.116	0.082	0.128	0.076	0.123	0.106
	2	First Reading	0.093	0.096	0.113	0.087	0.112	0.095
		Second Reading	0.116	0.108	0.110	0.079	0.094	0.113
		Third Reading	0.141	0.094	0.099	0.080	0.112	0.112
Correction Values (Average of the Six Readings)			0.114	0.099	0.109	0.081	0.104	0.112

Transfer Correction Values to the 'Correction Value' column of the LBP Testing Data Sheet form corresponding to each substrate.

Notes:

Form 7.3

Figure 7.6 Single-Family LBP Testing Example: "Substrate Correction Values" form.

Calibration Check Test Results

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Address/Unit No. 1994 Mapleton Avenue

Newtown, Maryland

Device XYZ Company, Inc. XRF I

Date March 15, 1995 XRF Serial No. BB-2295

Contractor ACME Pb Testing Inc.

Inspector Joe Smith

Inspector Signature Joseph Smith

Calibration Check Tolerance Used 1.0 mg/cm²

First Calibration Check

Red NIST SRM 1.02 mg/cm²			First Average	Difference Between First Average and 1.02 mg/cm²*
First Reading	Second Reading	Third Reading		
1.523	1.441	0.998	1.321	0.301

Second Calibration Check

Red NIST SRM 1.02 mg/cm²			Second Average	Difference Between Second Average and 1.02 mg/cm²*
First Reading	Second Reading	Third Reading		
1.442	1.102	1.009	1.184	0.164

Third Calibration Check *(if required)*

Red NIST SRM 1.02 mg/cm²			Third Average	Difference Between Third Average and 1.02 mg/cm²*
First Reading	Second Reading	Third Reading		

Fourth Calibration Check *(if required)*

Red NIST SRM 1.02 mg/cm²			Fourth Average	Difference Between Fourth Average and 1.02 mg/cm²*
First Reading	Second Reading	Third Reading		

* If the difference of the Calibration Check Average from the red NIST SRM 1.02 mg/cm² film value is greater than the specified Calibration Check Tolerance for this device, consult the manufacturer's recommendations to bring the instrument back into control. Retest all testing combinations tested since the last successful calibration check test.

Form 7.2

Figure 7.7 Single-Family LBP Testing Example: "Calibration Check Test Results" form for the back-up XRF completed through the second set of calibration check readings.

Single-Family Housing LBP Testing Data Sheet

Page 1 of 5

Address/Unit No. 1994 Mapleton Ave, Newtown, Maryland Date March 15, 1995

Room Equivalent Kitchen

XRF Serial No. BB-2295 Inspector Signature Joseph Smith

Substrate	Component	Color	Test Locations	XRF Reading	Correction Value	Result	Classification (pos, neg, inc)	Laboratory Result	UNIT?	Final Classification
Wood	Baseboard	White	Wall 3, Center	0.952	0.112	1.055	INC	1.210	mg/cm² %	POS
			Wall 3, Left	1.106						
			Wall 3, Right, below outlet	1.442						
Plaster	Wall	White	Wall 3, High center	0.661	0.104	0.494	INC	0.892	mg/cm² %	NEG
			Wall 3, Low center	0.598						
			Wall 3, Mid right, just to left of outlet	0.535						
Wood	Door	Brown	Wall 2, Top center	1.039	0.112	1.007	INC	1.311	mg/cm² %	POS
			Wall 2, Lower left quadrant	1.101						
			Wall 2, Center	1.217						
Wood	Window Casing	Yellow	Wall 2, Left window, top center	2.615	0.112	1.952	POS	N/A	mg/cm² %	POS
			Wall 2, Left window, right center	2.110						
			Wall 2, Left window, bottom of left side	1.463						
Wood	Window Casing	Green	Wall 1, Top of right side	0.922	0.112	0.638	INC	0.772	mg/cm² %	NEG
			Wall 1, Center of left side	0.559						
			Wall 1, Bottom of right side	0.789						
Metal	Heating Duct	White	Wall 1, Right side	1.996	0.081	2.370	POS	N/A	mg/cm² %	POS
			Wall 1, Center	2.917						
			Wall 1, Left side	2.446						
Plaster	Closet Wall	Green	Wall 1, Left of door, low	0.241	0.104	0.127	NEG	N/A	mg/cm² %	NEG
			Wall 1, Above door	0.276						
			Wall 1, Right of door, center	0.176						
Wood	Cabinet	Brown	Wall 1, Left cabinet door	0.234	0.112	0.113	NEG	N/A	mg/cm² %	NEG
			Wall 1, Right cabinet door	0.218						
			Wall 1, Left side of cabinet	0.223						
Metal	Door Casing	Blue	Wall 2, Above door	0.359	0.081	0.444	INC	0.552	mg/cm² %	NEG
			Wall 2, Left side, low	0.665						
			Wall 2, Right side, mid	0.552						

Form 7.1

Figure 7.8 Single-Family Housing LBP Testing Example: "Single-Family Housing LBP Testing Data Sheet" fully completed for the kitchen.

Single-Family Housing LBP Testing Data Sheet

Page 2 of 5

Address/Unit No. 1994 Mapleton Ave, Newtown, Maryland

Date March 15, 1995

Room Equivalent Bedroom

XRF Serial No. BB-2295

Inspector Signature Joseph Smith

Substrate	Component	Color	Test Locations	XRF Reading	Correction Value	Result	Classification (pos, neg, inc)	Laboratory Result	UNIT?	Final Classification
Drywall	Wall	White	Wall 3, Middle left	0.114	0.109	0.069	NEG	N/A	mg/cm² %	NEG
			Wall 3, High Center	0.222						
			Wall 3, Low right	0.168						
Wood	Shelf	Red	Wall 3, Closet, left side	1.095	0.112	1.122	INC	1.296	mg/cm² %	POS
			Wall 3, Closet, center	1.552						
			Wall 3, Closet, right	1.115						
Wood	Door Casing	Brown	Wall 1, Above door	2.669	0.112	2.601	POS	N/A	mg/cm² %	POS
			Wall 1, Right side, low	2.912						
			Wall 1, Left side, low	2.557						
Drywall	Closet Wall	White	Wall 3, High center	1.033	0.109	0.912	INC	0.923	mg/cm² %	NEG
			Wall 3, Low center	1.101						
			Wall 3, Middle right	0.929						
Wood	Chair Rail	Brown	Wall 2, Right	0.465	0.112	0.583	INC	0.449	mg/cm² %	NEG
			Wall 2, Left	0.666						
			Wall 2, Center	0.955						
Plaster	Wall	White	Wall 1, Low center	0.712	0.104	0.552	INC	1.328	mg/cm² %	POS
			Wall 1, Low left	0.601						
			Wall 1, Middle right	0.655						
Plaster	Wall	White	Wall 4, High left	0.991	0.104	0.711	INC	1.119	mg/cm² %	POS
			Wall 4, Low center	0.880						
			Wall 4, High right	0.754						
									mg/cm² %	
									mg/cm² %	

Form 7.1

Figure 7.9 Single-Family Housing LBP Testing Example: "Single-Family Housing LBP Testing Data Sheet" fully completed for the bedroom.

ACME Pb Testing, Inc.
LEAD TESTING CONSULTANTS
23741 ANYWHERE STREET, SUITE 714
NEWTOWN, MD 21840

(301) 555-3123
FAX (301) 555-3[illegible]

March 21, 1995

LEAD INSPECTION FINAL SUMMARY REPORT

XRF Manufacturer:	**XYZ Company, Inc.**	XRF Device:	**XRF I**
Operator:	**Joseph Smith**	XRF Serial No.:	**BB-2295**
License Number:	**XY123**		
Inspection Date:	**March 15, 1995** **8:15 a.m. to 2:40 p.m.**	Inspection Site:	**1994 Mapleton Ave.** **Newtown, Maryland**

120 testing combinations were tested within the above identified house. Lead in quantities greater than the HUD standard was found in paint on 7 of the 120 testing combinations.

Room Equivalent	Substrate	Component	Color
Kitchen	Wood	Baseboard	White
	Wood	Door	Brown
	Wood	Window casing	Yellow
	Metal	Air duct	White
Bedroom	Wood	Shelf	Red
	Wood	Door casing	Brown
	Plaster	Walls	White

Figure 7.10 Single-Family LBP Testing Example: Lead Inspection Final Summary Report.

For multifamily housing, only a random sample of units needs to be inspected to determine if lead-based paint is present. The results of the sample are grouped, thus allowing the application of the decision rules described below. A sufficient amount of data is collected for decisions to be made regarding the number of surfaces containing lead-based paint.

A. Selection of Housing Units

The first step in selecting units for inspection is to identify (based on written documentation or visual evidence) buildings in the development with a common construction and painting history. Such buildings can be grouped together for sampling purposes. Conclusions made from sampled units will better reflect the lead-based paint present in the unsampled units if multifamily buildings or units can be divided into groups with a common construction and painting history. For example, if two buildings in the development were built at the same time by the same builder and appear to be of similar construction, all of the units in the two buildings can be grouped for sampling purposes. Units can have different sizes, floor plans, and number of bedrooms and still meet the criterion of commonality.

The number of units to be tested (the "sample size") is based on the total number of units in the building or buildings as specified in Table 7.3. When *all* tested units are found to be clear of lead above the 1.0 mg/cm^2 standard, these sample sizes provide 95-percent confidence that fewer than 5 percent of all the units in the building(s) (or 50 units, whichever is less) contain lead-based paint at or above the 1.0 mg/cm^2 standard, assuming no sampling error within units. Appendix 12 presents the statistical rationale and calculations used to develop sample sizes in multifamily housing.

The specific units to be tested should be chosen *randomly* from a list of all units in each building or buildings. The "Selection of Units" form (Form 7.4) or a comparable form may be used to aid in the selection process. A *complete* list of all units in each group should be used. Obviously, missing units cannot be selected for inspection, thereby biasing the sampling scheme. The list of units should be verified by consulting building plans or by a physical inspection of the development. The units on the list from which random selections will be made should be sequentially numbered.

The specific units to be tested should be selected randomly using the formula below and a table of random numbers or the random number function on a handheld calculator. Tables of random numbers are often included in statistics books. However, since handheld calculators with a random number function key can be obtained for less than $20 and are easier to use than tables, inspector technicians are advised to use them to obtain the random numbers.

The random numbers can be used to select the specific numbered units. A unit number is selected by rounding up the product of the random number times the total number of units in the development. That is,

Unit number = Round up (Random number x Total number),

where:

- Unit number = the identification number for a unit in a list;
- Random number = a random number between 0 and 1, inclusive; and
- Total number = the total number of units in a list of units.

It is possible that the same unit will be selected twice by this procedure. Since each unit should be tested only once, the duplicate selection is discarded. This procedure continues until an adequate number of units has been selected.

The "Selection of Units" form (Form 7.4) is completed by filling in as many random numbers as needed in the appropriate column. The numbers for the third column are obtained by multiplying the total development size by each random number. The numbers for the fourth column are obtained by rounding up from the previous calculation. If the value for the fourth column has already been selected, that selection should not be numbered. “DUP” should be entered to indicate that the selection was a duplicate. This process should continue until the required number of distinct sample numbers have been selected. Common areas and exterior room equivalents should be identified at this time, but they are not considered to be separate units.

B. Inventory and Selection of Painted Surfaces

The “Multifamily Housing LBP Testing Data Sheet” form (Form 7.5) or comparable form should be used to carry out the inventory of painted surfaces in each unit that was selected for inspection. An inventory may be completed prior to any XRF testing or it may be done on a room-by-room basis, that is, for each room equivalent during testing. Like single-family housing, the inventory lists are comprised of testing combinations. A *testing combination* is characterized by the combination of a room equivalent, substrate, component, and color. In multifamily housing, the inventory of testing combinations will be very similar for units that have the same number of bedrooms. However, the inspector technician should be sure to list the testing combinations that are unique to each tested unit. For example, some units may contain built-in cabinets while others may not. Therefore, the selection of test locations should be carried out independently in each inspected unit. In multifamily housing, each common area (e.g., building lobby, laundry room) is considered to be a room equivalent (not a dwelling unit) for inventory purposes. All room equivalents, whether they are interior rooms, common areas, or exterior surfaces or areas, need to be included in the inventory of the housing. Inspector technicians may find master plans for the housing development to be useful in performing the inventory.

C. Number of Readings on Each Testing Combination

XRF readings are collected in the same manner for multifamily housing as for single-family housing with one exception: A single XRF reading is taken on a testing combination instead of three XRF readings. A single reading is acceptable due to the lower variability found in multifamily housing and the larger sample sizes. The selection of a single test location should be varied so that the universe of samples for each type of component in the multifamily development reflects the inspection of lead-based paint at a variety of locations. For example, if there are 60 exterior doors to be tested, 20 of them should be tested on the lower third of the door, 20 in the middle third, and the other 20 on the top third. Each door will require only one XRF reading.

D. XRF Calibration Check Readings

XRF calibration check readings should be collected in each unit in the same manner as described for single-family housing (see Section IV of this chapter).

E. Substrate Correction in Multifamily Housing

The method for correcting XRF readings for substrate bias should be performed as described for single-family housing with one exception: One representative location of a given substrate should be selected from each of two randomly chosen units for each substrate type.

F. Classification of XRF Results in Multifamily Housing

The inspector technician should record each XRF reading for each testing combination on the “Multifamily Housing LBP Testing Data Sheet,” (Form 7.5) or a comparable form and indicate whether that testing combination was classified as positive, negative, or inconclusive as described for single-family housing.

When the inspection is completed in all of the selected units and the classification rules have been applied to all of the XRF results, the “Multifamily Housing: Component Type Report” form (Form 7.6) or a comparable form should be completed. This form aggregates

Table 7.3 Number of Units To Be Tested in Multifamily Developments

Number of Units in Building or Group of Similar Buildings	Number of Units To Be Tested
<20	All
20–26	20
27	21
28	22
29–30	23
31	24
32	25
33–34	26
35	27
36	28
37	29
38–39	30
40–50	31
51	32
52–53	33
54	34
55–56	35
57–58	36
59	37
60–73	38
74–75	39
76–77	40
78–79	41
80–95	42
96–97	43
98–99	44
100–117	45
118–119	46
120–138	47
139–157	48
158—177	49
178–197	50
198–218	51
219–258	52
259–299	53
300–379	54
380–499	55
500–776	56
777–1,004	57
1,005–1,022	58
1,023–1,039	59

For buildings or groups of similar buildings with 1,040 units or more, 5.8 percent of the number of units should be tested, rounded to the nearest unit. EXAMPLE: If there are 2,170 units, 5.8 percent multiplied by the number of units equals 125.86, so 126 units should be tested.

NOTE: EPA and HUD are currently conducting research to determine if the number of dwelling units to be sampled in multifamily developments can be reduced. It is expected that revisions to this table, if any, will be published in the fall of 1995.

component types in the multifamily housing development. A *component type* is a group of like components constructed of the same substrate. For example, grouping all walls would create an appropriate component type if all walls are plaster. However, grouping all doors would not be appropriate if some doors are metal and some doors are wood. At least 40 components of a given type must be tested to obtain the desired level of confidence in the results throughout the multifamily housing development. (Refer to Appendix 12 for the statistical rationale for this minimum number of component types to test.) If less than 40 components of a given type were tested using XRF instruments, additional components will need to be tested. If less than 40 components of a given type exist in the buildings to be tested, further XRF testing is not necessary. In this case, three readings should be taken on each testing combination, as is the case in single-family housing.

To increase the number of tested components of a given type (and to decrease the number of entries in the “Multifamily Housing: Component Type Report” form), testing combinations with different colors on the same component and substrate may be combined into a single component type. For example, if “wooden doors” is the component type, all wooden doors tested for lead-based paint could belong to the same component type regardless of color. In some instances it may be preferable to differentiate component types by color. For example, it may be desirable to group red wooden doors as one component type and white wooden doors as another component type.

In some cases additional sampling of the specific component may not be necessary. If no lead at or above the standard is found on the component, additional samples should be taken in other units to increase the sample size to 40. But if the sampled components contain high amounts of lead, it may be concluded without further sampling that lead-based paint is present greater than or equal to 1.0 mg/cm^2 on all components. For example, if 20 out of 60 doors are tested, and all have lead levels of 1.0 mg/cm^2 or greater, it may be concluded that all doors in the buildings are positive for lead. However, the converse does not apply. *All* of the required XRF testing must be completed to conclude that all components included in a given component type are negative for lead.

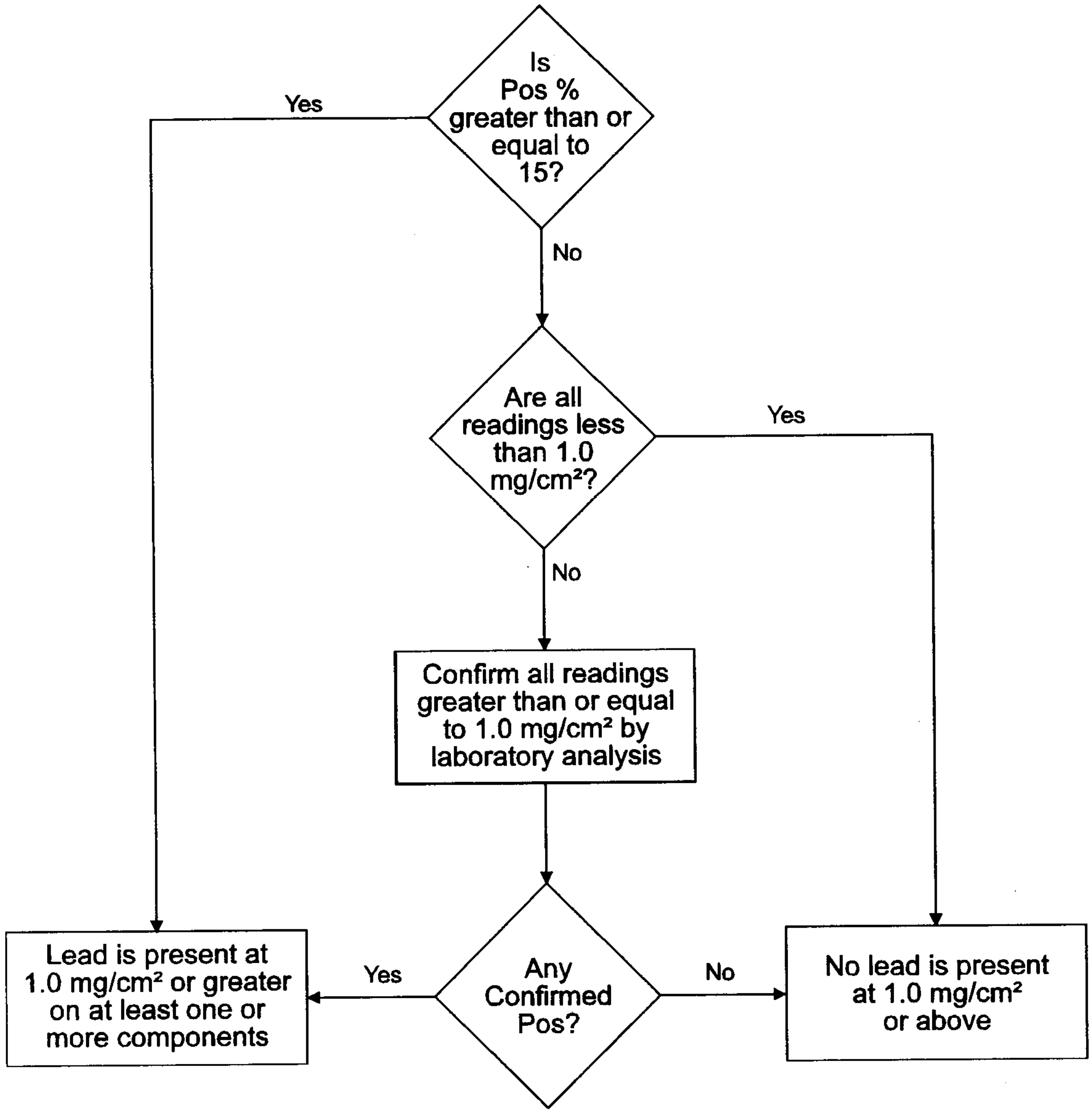
On the “Multifamily Housing: Component Type Report” form, the substrate, component, and color (if necessary) for each component type should be recorded under “Description” (for example, wooden doors) as well as the total number of testing combinations included in the component type. Further, for each component type, the aggregated positive, negative, and inconclusive classifications should be recorded as described below. Record the number and percentage of testing combinations classified as:

- ❖ Positive relative to the HUD standard.
- ❖ Inconclusive *and* having XRF readings less than 1.0 mg/cm^2.
- ❖ Inconclusive *and* having XRF readings equal to or greater than 1.0 mg/cm^2.
- ❖ Negative.

The percentages are computed by dividing the number in each classification group by the total number of testing combinations in the component type. For example, if there are 245 wooden doors in a multifamily housing development and 69 of them were classified as inconclusive with XRF readings less than 1.0 mg/cm^2, then 28 percent [(69 ÷ 245) x 100 = 28.2%] should be recorded on the form in the “<1.0 mg/cm^2 Percent” columns under the “INCONCLUSIVE” heading.

The “Multifamily Decision Flowchart” (Figure 7.11) should be used to interpret the aggregated XRF testing results in the “Multifamily Housing: Component Type Report” form. The XRF Performance Characteristics Sheet will specify which XRF instruments apply to the flowchart. The flowchart is applied separately to each component type (doors, window casings, etc.) and indicates one of the following results:

Positive: Lead is present at or above the HUD standard of 1.0 mg/cm^2 on *one or more* of the components.



- Pos is the positive classification of a testing combination relative to the HUD standard as specified in the *XRF Performance Characteristics Sheet* for each XRF instrument.

Figure 7.11 Multifamily Decision Flowchart.

Negative: Lead is not present on any of the components at or above the HUD standard of 1.0 mg/cm^2. Note that lead may still be present and hazardous leaded dust may be generated during modernization, renovation, remodeling, maintenance, or other disturbances of painted surfaces.

These results are obtained by following the flowchart. The decision that lead is present at or above 1.0 mg/cm^2 is reached if 15 percent or more of the components are positive. (Refer to Appendix 12 for the statistical rationale for this percentage.) The decision that no lead is present is reached if 1) 100 percent of the tested component types are negative, or 2) 100 percent of the tested component types are classified as either negative or inconclusive *and* all of the inconclusive classifications have XRF readings less than 1.0 mg/cm^2. For all other cases, confirmatory laboratory testing is required. For each component with an inconclusive XRF reading of 1.0 mg/cm^2 or greater, a paint-chip sample should be removed (following the protocol outlined in this chapter) and sent to a laboratory recognized by NLLAP for analysis. If *any* laboratory results are 1.0 mg/cm^2 (or 0.5 percent) or greater, a positive result is indicated. Once all laboratory results have been returned, the "Multifamily Housing: Component Type Report" form should be updated to include the laboratory results and classifications (either positive or negative).

The percentages used in the "Multifamily Decision Flowchart" are based on data collected by EPA in a large field study of XRF instruments.[3] The percentages were chosen so that, for each component type, there is a 98-percent chance of correctly concluding that lead-based paint is either absent on all components or present on at least one component of a given type. Thus, there is a very high probability that a tested component type will be correctly classified. Combined with the 95-percent probability that at least one leaded component will be selected for inspection by the sampling scheme when 5 percent or more of the components contain lead-based paint at or above 1.0 mg/cm^2, the inspection procedure provides an overall confidence level of between 93 and 95 percent, given the distribution of lead-based paint in U.S. housing.

The XRF testing and decision flowchart, including laboratory confirmation, do not indicate which specific components have tested positive for lead. The positive result merely shows that *one or more* components contain lead at or above 1.0 mg/cm^2. However, in some cases, it may be more cost effective to test *all* components of the given type (using single-family housing inspection procedures) to determine which are above the 1.0 mg/cm^2 standard, depending on the costs of lead hazard control treatment for the type of component.

1. Unsampled Housing Units

The approach described for multifamily housing is designed to use a sample of units to identify component types that are very likely to be negative for lead (relative to the HUD standard) in *all* units of the development, both sampled and unsampled. Once these component types are identified, no further testing resources need to be allocated for components of those types. Furthermore, if lead is present on a component type, this approach is very likely to identify *at least one* component of that type as having lead-based paint relative to the HUD standard.

If part of a particular component type in the sampled units is positive for lead relative to the HUD standard, then one would conclude that same part of the same component type in the unsampled units is also positive for lead. Identifying which specific components of the given type are positive for lead in the unsampled units is a difficult task, and careful attention to the allocation of testing resources is recommended. For those cases where the number of positive component types is small (i.e., only a few positives are found), the purchaser of the inspection services may choose to use the sample results in conjunction with building records to determine if there is a systematic reason for the specific mixture of positive and negative results.

For example, suppose that porch railings (a component type) were present in all units. A sample of these porch railings was inspected for lead-based paint and the results were classified as both negative and positive. Examination of the sample results in conjunction with the building records revealed that the porch railings that were classified as positive were all original and that the porch railings that were classified as negative were all recently replaced. The owner was then able to make conclusions about the unsampled porch railings. The owner concluded that 1) all of the unsampled original porch railings could be classified as positive, and 2) all of the unsampled porch railings that were recently replaced could be classified as negative if at least 40 of the replaced porch railings had been sampled.

For cases where 5 percent or less of a particular component type in the sampled units are positive for lead relative to the HUD standard, the purchaser of the inspection services may choose to take a second random sample, particularly if the use of building records does not resolve all issues. The same procedure should be used when selecting units for the second sample—the same number of units should be selected as for the first sample, and selections should only be taken from the list of unsampled units.

If the combination of the two samples for a particular component type results in fewer than 2 1/2 percent positive classifications, the owner may bring testing to a conclusion in order to avoid continuing to expend resources on difficult-to-find components coated with lead-based paint. Individual components in the samples that were classified as positive for lead-based paint relative to the HUD standard should be managed appropriately. If there are components classified as positive in the second sample, the owner should arrange for testing of the unsampled components in the remaining units at a convenient time, such as during unit vacancy or before renovation, or simply assume that all untested components are positive.

If the two samples combined have 2 1/2 percent or more components of a given type that are classified as positive, then further testing of all components of that type or further investigation of building records in conjunction with the two sample results is required to determine where the lead-based paint is located.

Whatever approaches are used, all painted surfaces found to be positive for lead relative to the HUD standard must be reported.

G. Paint-Chip Collection and Laboratory Analysis

These procedures are the same as for single-family housing (see Section IV of this chapter).

H. Evaluation of the Inspection

The options for evaluating the inspection services in multifamily housing are the same as those described for single-family housing except for the retesting option. In multifamily housing, a total of 10 testing combinations should be selected for retesting in 2 units.

At a minimum, the retesting option should be used; however, a combination of all four methods would be best. If results from the retesting option suggest that XRF testing was not performed as reported, a complete audit of the inspection should be conducted. The inspection contract should outline the financial penalties or more serious penalties if an audit reveals systematic noncompliance with the inspection contract or fraud.

I. Documentation in Multifamily Housing

Documentation of the inspection in multifamily housing should be done as described for single-family housing with one exception: The forms for multifamily housing at the end of this chapter or comparable forms should be used instead of the single-family housing forms (see Section IV of this chapter).

J. Example of Multifamily Housing Inspection

This section presents an example of the inspection of a multifamily housing development. An actual inspection of a multifamily housing development will have many more testing combinations than are given in this example. First, the inspector technician physically examined the development to be tested, identifying buildings with a common construction and painting history. The inspector technician found that all units within this development were similar enough in construction and painting history to be grouped together for sampling purposes. The inspector technician then determined that there were a total of 55 units within this development and by consulting Table 7.3, found that 35 units should be inspected.

The inspector technician used the "Selection of Units" form (Figure 7.12) to randomly select the units to inspect. The total number of units, 55, was entered into the first column of the form. The random numbers that were generated from a handheld calculator were entered into the second column. The first random number was 0.583, which was multiplied by 55 (the total number of units) and the product was entered in the third column. The product was rounded up (33) and written in the fourth column; thus, the 33rd unit was the unit selected. Other units were selected using the same formula. If a unit previously selected was chosen again, the inspector technician crossed out the repeated unit number and wrote "DUP" (for duplicate) in the last column. The inspector technician continued generating random numbers until 35 distinct units had been selected for inspection. (In this case, it would have been more efficient to randomly determine the 20 units that would *not* be inspected (55 – 35 = 20) and then to select the remaining 35 units for inspection.)

After identifying the units to be inspected, an inventory of all painted surfaces within the selected units was conducted. The inspector technician completed the "Multifamily Housing LBP Testing Data Sheet" for every testing combination found in each room equivalent within each unit. Figure 7.13 is an example of the completed inventory for the bedroom of the first unit to be inspected. The inventory showed that the bedroom was composed of four substrates and eight testing combinations of the following components: 1) one ceiling beam, 2) two doors, 3) four walls, 4) one window casing, 5) two door casings, 6) three shelves, 7) two support columns, and 8) one radiator. For the components that were replicated, a single replicate was randomly selected for XRF testing. The location descriptions were recorded in the "Test Location" column. Drywall, brick, and metal substrates were not present in the bedroom.

Testing combinations that were not common to all units were added to the inventory list. The inspector technician also noted which common areas and exterior areas were associated with the selected units, identified each of these common and exterior areas as a room equivalent, and inventoried the corresponding testing combinations.

The inspector technician inventoried the remaining 34 units that were selected and their associated common areas and exterior areas before beginning XRF testing for lead-based paint in the housing development. Alternatively, the inspector technician could have inventoried each room equivalent as XRF testing proceeded.

After completing the inventory, the inspector technician performed the manufacturer's recommended warmup and quality control procedures successfully. Then the inspector technician took three calibration check readings on the red NIST SRM film. This was done by attaching the film to a wooden board and holding the board so that the film was in front of the probe. The readings were then taken making sure that the probe was at least 12 inches from any source of extraneous lead. Results of these calibration check readings were recorded on the "Calibration Check Test Results" form (Figure 7.14). The difference between the first calibration check average and 1.02 mg/cm^2 was less than the 1.0 mg/cm^2 calibration check tolerance obtained from the *XRF Performance Characteristics Sheet* (Figure 7.15), indicating that the XRF instrument was in control and that XRF testing could begin. (See the single-family housing example for a description of what to do when the calibration check tolerance is exceeded.)

The inspector technician began XRF testing in the bedroom by taking one reading on each testing combination listed on the inventory data sheet. XRF testing continued until all concrete, wood, and plaster components were

Selection of Units

Page 1 of 5

Testing Site: Sun City Housing Complex

Date: March 16 1995

Total Number of Units	Random Number*	Random Number times Total Number of Units Product	Round up for Unit Number to Sample	Sample Number
55	0.583	32.065	33	1
55	0.107	5.885	6	2
55	0.873	48.015	49	3
55	0.085	4.675	5	4
55	0.961	52.855	53	5
55	0.111	6.105	7	6
55	0.575	31.625	32	7
55	0.241	13.255	14	8
55	0.560	30.800	31	9
55	0.884	48.620	~~49~~	DUP
55	0.341	18.755	19	10
55	0.851	46.805	47	11
55	0.574	31.570	~~32~~	DUP
55	0.221	12.155	13	12
55	0.103	5.665	~~6~~	DUP
55	0.375	20.625	21	13
55	0.625	34.375	35	14
55	0.395	21.725	22	15
55	0.095	5.225	~~6~~	DUP
55	0.772	42.460	43	16
55	0.761	41.855	42	17
55	0.515	28.325	29	18
55	0.855	47.025	48	19
55	0.679	37.345	38	20
55	0.635	34.925	~~35~~	DUP
55	0.622	34.210	~~35~~	DUP
55	0.323	17.765	18	21
55	0.431	23.705	24	22
55	0.921	50.655	51	23
55	0.189	10.395	11	24
55	0.349	19.195	20	25
55	0.031	1.705	2	26

* Obtained from a hand-held calculator

Form 7.4

Figure 7.12 Multifamily LBP Testing Example: "Selection of Units" form.

Selection of Units

Page _2_ of _5_

Testing Site _Sun City Housing Complex_ Date _March 16, 1995_

Total Number of Units	Random Number*	Random Number times Total Number of Units Product	Round up for Unit Number to Sample	Sample Number
55	0.735	40.425	41	27
55	0.929	51.095	52	28
55	0.229	12.595	~~13~~	DUP
55	0.267	14.685	15	29
55	0.155	8.525	9	30
55	0.284	15.620	16	31
55	0.447	24.585	25	32
55	0.487	26.785	27	33
55	0.721	39.655	40	34
55	0.603	33.165	34	35

* Obtained from a hand-held calculator

Form 7.4

Figure 7.12 (cont.) Multifamily LBP Testing Example: "Selection of Units" form.

Multifamily Housing LBP Testing Data Sheet

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Address/Unit No. San City Housing Complex Date March 16, 1994

Room Equivalent Bedroom

XRF Serial No. RC-2100 Inspector Signature Joseph Smith

Substrate	Component	Color	Replication Number	Test Location	XRF Reading	Correction Value	Corrected Reading	Classification (pos. neg. inc)	Laboratory Result	UNIT?	Laboratory Classification
Concrete	Ceiling Beam	White	1	Wall 1	0.891	N/A	N/A	INC		mg/cm² %	
Wood	Door	Brown	2	Closet Door	1.125	N/A	N/A	INC		mg/cm² %	
Plaster	Walls	White	4	Wall 1	0.261	N/A	N/A	NEG		mg/cm² %	
Wood	Window Casing	Brown	1	Wall 3	1.271	N/A	N/A	INC		mg/cm² %	
Wood	Door Casing	Green	2	Wall 4	2.531	N/A	N/A	POS		mg/cm² %	
Wood	Shelves	Green	3	Wall 2, side	0.221	N/A	N/A	NEG		mg/cm² %	
Concrete	Support Column	White	2	Corner of Walls 2 and 3	0.101	N/A	N/A	NEG		mg/cm² %	
Metal	Radiator	Brown	1	Wall 1	0.736	N/A	N/A	INC		mg/cm² %	
										mg/cm² %	
										mg/cm² %	
										mg/cm² %	
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										mg/cm² %	

Form 7.5

Figure 7.13 Multifamily Housing LBP Testing Example: "Multifamily Housing LBP Testing Data Sheet" form with completed testing combination inventory of the bedroom.

Calibration Check Test Results

Page 4 of 5

Address/Unit No. Sun City Housing Complex

Device ABC Company Inc. XRF1

Date March 16, 1995 Serial No. RC-2100

Contractor ACME Pb Testing Inc.

Operator Joe Smith

Operator Signature Joseph Smith

Calibration Check Tolerance Used 1.0 mg/cm²

First Calibration Check

Red NIST SRM 1.02 mg/cm²			First Average	Difference Between First Average and 1.02 mg/cm²*
First Reading	Second Reading	Third Reading		
1.068	0.998	1.103	1.056	0.036

Second Calibration Check

Red NIST SRM 1.02 mg/cm²			Second Average	Difference Between Second Average and 1.02 mg/cm²*
First Reading	Second Reading	Third Reading		
1.112	1.261	1.003	1.125	0.105

Third Calibration Check *(If required)*

Red NIST SRM 1.02 mg/cm²			Third Average	Difference Between Third Average and 1.02 mg/cm²*
First Reading	Second Reading	Third Reading		

Fourth Calibration Check *(If required)*

Red NIST SRM 1.02 mg/cm²			Fourth Average	Difference Between Fourth Average and 1.02 mg/cm²*
First Reading	Second Reading	Third Reading		

* If the difference of the Calibration Check Average from the red NIST SRM 1.02 mg/cm² film value is greater than the specified Calibration Check Tolerance for this device, consult the manufacturer's recommendations to bring the instrument back into control. Retest all room equivalents tested since the last successful Calibration Check test.

Form 7.2

Figure 7.14 Multifamily LBP Testing Example: "Calibration Check Test Results" form completed through the initial calibration check readings.

EXAMPLE OF AN XRF PERFORMANCE CHARACTERISTICS SHEET

EFFECTIVE DATE: 3/01/95

MANUFACTURER AND MODEL:

Make: *ABC Company, Inc.*
Model: *XRF I*
Note: This Sheet supersedes all previous Sheets for the make and model of XRF instrument shown above

EVALUATION DATA SOURCE AND DATE:

Performance parameters shown in this Sheet are calculated from evaluation data collected during *EPA/HUD field evaluation study, report dated 2/28/95*

OPERATION PARAMETERS:

Performance parameters shown in this Sheet are applicable only when operating the above indicated XRF instrument under the conditions used during the evaluation testing. These operating parameters include:

- Manufacturer recommended warm-up quality control procedures
- Use the Multifamily Decision Flowchart for determining the presence of lead on a component type
- Nominal 15-second readings

SUBSTRATE CORRECTION NEEDED ON:

None

SUBSTRATE CORRECTION NOT NEEDED ON:

Brick, Concrete, Drywall, Metal, Plaster, and Wood

ITEM	GUIDANCE	VALUES
Inconclusive Range Limits (without substrate correction)	Readings without substrate bias correction	Brick = 0.15 to 1.12 Concrete = 0.18 to 1.09 Drywall = -0.01 to 1.01 Metal = 0.27 to 1.12 Plaster = 0.41 to 1.25 Wood = 0.62 to 1.45
Calibration Check Tolerance	Calibration Check Tolerance limits for this instrument	± 1.0 mg/cm²
Bias* (without substrate correction)	Measured at 0.0 mg/cm²	-0.55 mg/cm² for brick -0.59 mg/cm² for concrete -0.35 mg/cm² for drywall 0.31 mg/cm² for metal 0.59 mg/cm² for plaster -0.04 mg/cm² for wood
	Measured at 1.0 mg/cm²	-0.73 mg/cm² for brick -0.33 mg/cm² for concrete -0.62 mg/cm² for drywall 0.46 mg/cm² for metal -0.42 mg/cm² for plaster 0.35 mg/cm² for wood
Precision* (without substrate correction)	Measured at 0.0 mg/cm²	0.76 mg/cm² for brick 0.75 mg/cm² for concrete 0.48 mg/cm² for drywall 0.33 mg/cm² for metal 0.70 mg/cm² for plaster 0.47 mg/cm² for wood
	Measured at 1.0 mg/cm²	0.77 mg/cm² for brick 0.89 mg/cm² for concrete 0.42 mg/cm² for drywall 0.48 mg/cm² for metal 0.78 mg/cm² for plaster 0.66 mg/cm² for wood

*Do not use these bias or precision data to correct for substrate effects on a specific surface. Actual bias must be determined on the site (see HUD Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing).

Figure 7.15 Example of an XRF Performance Characteristics Sheet.

Multifamily Housing LBP Testing Data Sheet

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Address/Unit No. Sun City Housing Complex — Date March 16, 1994

Room Equivalent Bedroom

XRF Serial No. RC-2100 — Inspector Signature Joseph Smith

Substrate	Component	Color	Replication Number	Test Location	XRF Reading	Correction Value	Corrected Reading	Classification (pos. neg. inc)	Laboratory Result	UNIT?	Laboratory Classification
Concrete	Ceiling Beam	White	1	Wall 1	0.891	N/A	N/A	INC		mg/cm^2 %	
Wood	Door	Brown	2	Closet Door	1.126	N/A	N/A	INC		mg/cm^2 %	
Plaster	Walls	White	4	Wall 1	0.261	N/A	N/A	NEG		mg/cm^2 %	
Wood	Window Casing	Brown	1	Wall 3	1.211	N/A	N/A	INC		mg/cm^2 %	
Wood	Door Casing	Green	2	Wall 4	2.531	N/A	N/A	POS		mg/cm^2 %	
Wood	Shelves	Green	3	Wall 2, side	0.221	N/A	N/A	NEG		mg/cm^2 %	
Concrete	Support Column	White	2	Corner of Walls 2 and 3	0.101	N/A	N/A	NEG		mg/cm^2 %	
Metal	Radiator	Brown	1	Wall 1	0.736	N/A	N/A	INC		mg/cm^2 %	
										mg/cm^2 %	
										mg/cm^2 %	
										mg/cm^2 %	
										mg/cm^2 %	
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Form 7.5

Figure 7.16 Multifamily Housing LBP Testing Example: "Multifamily Housing LBP Testing Data Sheet" form completed through XRF Classification.

inspected in the bedroom. The XRF readings were recorded on the “Multifamily Housing LBP Testing Data Sheet” form (Figure 7.16). According to the *XRF Performance Characteristics Sheet*, the XRF instrument in use did not require correction for substrate bias, so the XRF classification column was completed at this time. The inspector technician used the single-family housing rules for classifying the XRF readings as positive, negative, or inconclusive. The inspector techician also used the inconclusive ranges obtained from the *XRF Performance Characteristics Sheet*. The results of the classifications were recorded in the “Classification” column of the “Multifamily Housing LBP Testing Data Sheet” form. Classifications for all testing combinations within the unit were computed in the same manner as for the bedroom.

Once XRF testing in all rooms within this unit was completed, the inspector technician conducted a second set of calibration check readings.

The results were recorded on the “Calibration Check Test Results” form (Figure 7.17). The inspector technician computed the difference between the second calibration check average and 1.02 mg/cm^2 to be 0.105 mg/cm^2, indicating that the instrument remained in control, thus completing the inspection of this unit.

Inspections of all units within the development, and in all exterior and common areas, were completed using the same approach.

Once inspections were completed in all of the 35 selected units of the multifamily housing development, the inspector technician completed the “Multifamily Housing: XRF Component Type Report” form (Figure 7.18). A description of each component type was recorded in the first column, the total number of each tested component type was entered in the second column, and the number of testing combinations classified as positive for each component type from the “Multifamily Housing LBP Testing Data Sheet” was calculated and then entered in the third column. The inspector technician then did the same for the negative classifications, for inconclusive classifications with XRF readings less than 1.0 mg/cm^2, and for inconclusive classifications with XRF readings equal to 1.0 mg/cm^2 or greater. Using these numbers and the total number of the component type sampled, the inspector technician computed and recorded the percentages of positive, negative, and inconclusive classifications for each component type.

After entering the number of testing combinations for each component type in the “Multifamily Housing: Component Type Report” form, the inspector technician noticed that only 34 wood door casings had been inspected. Since it is necessary to test at least 40 testing combinations of each component type, the inspector technician arranged with the owner to test 6 more previouly untested door casings. Additional units were randomly selected from the list of unsampled units. An initial calibration check test was successfully completed and the six door casings were tested for lead-based paint. Another calibration check test indicated that the XRF instrument remained in control. The inspector technician then updated the “Multifamily Housing: Component Type Report” form by deleting the line that had too few component types for testing and including the information on wood door casings on a new line.

As specified in the *XRF Performance Characteristics Sheet*, the “Multifamily Decision Flowchart” (Figure 7.11) was applied to the component type results. Since 100 percent of the walls and baseboards were negative for lead, the inspector technician concluded that there was no lead-based paint at or above 1.0 mg/cm^2 on any walls or baseboards in the development, including those in uninspected units, and entered “NEG” in the “Overall Classification” column. Also, the inspector technician observed that the percentage of positive results was 15 percent or greater for all of the component types, with the exception of shelves, hall cabinets, and window casings. Since the flowchart indicated that one or more of these components were coated with lead-based paint, the inspector technician entered “POS” in the “Overall Classification” column. For shelves, hall cabinets, and window

Calibration Check Test Results

Page 4 of 5

Address/Unit No. Sun City Housing Complex

Device ABC Company, Inc. XRF I

Date March 16, 1995 Serial No. RC-2100

Contractor ACME Pb Testing Inc.

Operator Joe Smith

Operator Signature Joseph Smith

Calibration Check Tolerance Used 1.0 mg/cm²

First Calibration Check

Red NIST SRM 1.02 mg/cm²			First Average	Difference Between First Average and 1.02 mg/cm²*
First Reading	Second Reading	Third Reading		
1,068	0,998	1,103	1,056	0,036

Second Calibration Check

Red NIST SRM 1.02 mg/cm²			Second Average	Difference Between Second Average and 1.02 mg/cm²*
First Reading	Second Reading	Third Reading		
1,112	1,261	1,003	1,125	0,105

Third Calibration Check *(If required)*

Red NIST SRM 1.02 mg/cm²			Third Average	Difference Between Third Average and 1.02 mg/cm²*
First Reading	Second Reading	Third Reading		

Fourth Calibration Check *(If required)*

Red NIST SRM 1.02 mg/cm²			Fourth Average	Difference Between Fourth Average and 1.02 mg/cm²*
First Reading	Second Reading	Third Reading		

* If the difference of the Calibration Check Average from the red NIST SRM 1.02 mg/cm² film value is greater than the specified Calibration Check Tolerance for this device, consult the manufacturer's recommendations to bring the instrument back into control. Retest all room equivalents tested since the last successful Calibration Check test.

Form 7.2

Figure 7.17 Multifamily LBP Testing Example: "Calibration Check Test Results" form completed through the second set of calibration check readings.

Multifamily Housing: Component Type Report

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Address/Unit No. Sun City Housing Complex

Newtown, Maryland

Date March 16, 1995 XRF Serial No. RC-2100

Inspector Signature Joseph Smith

Description	Total Number	POSITIVE		INCONCLUSIVE				NEGATIVE		Final Class.
				< 1.0 mg/cm²		≥1.0 mg/cm²				
		Number	Percent	Number	Percent	Number	Percent	Number	Percent	
Wood Shelves	83	7	8.4	5	6.0	9	10.8	62	74.7	INC
Wood Doors	110	40	36.4	12	10.9	8	7.3	50	45.5	POS
~~Wood Door Casings~~	~~34~~	~~6~~	~~17.6~~	~~5~~	~~14.7~~	~~5~~	~~14.7~~	~~18~~	~~52.9~~	
Wood Hall Cabinets	60	6	10.0	3	5.0	16	26.7	35	58.3	INC
Wood Window Stools	110	60	54.5	30	27.3	10	9.1	10	9.1	POS
Wood Window Casings	63	0	0.0	21	33.3	3	4.8	39	61.9	INC
Plaster Walls	110	0	0.0	0	0.0	0	0.0	110	100	NEG
Concrete Support Columns	40	40	100	0	0.0	0	0.0	0	0.0	POS
Concrete Ceiling Beams	40	40	100	0	0.0	0	0.0	0	0.0	POS
Metal Baseboards	45	0	0.0	0	0.0	0	0.0	45	100	NEG
Metal Gutters	50	20	40.0	8	16.0	2	4.0	20	40.0	POS
Brick Stairway	50	10	20.0	4	8.0	6	12.0	30	60.0	POS
Metal Radiators	55	14	25.5	7	12.7	3	5.5	31	56.4	POS
Wood Door Casings	40	12	30.0	5	12.5	5	12.5	18	45.0	POS

Form 7.6

Figure 7.18 Multifamily LBP Testing Example: "Component Type Report" form.

casings, the XRF results were inconclusive, so the inspector technician entered "INC" in the "Overall Classification" column. Since three of the component types were classified as "INC", the inspector technician noted from the flowchart that laboratory confirmatory testing of all those components with XRF readings equal to or greater than 1.0 mg/cm^2 was required.

The inspector technician arranged for the collection of paint-chip samples from the inconclusive component types, but only from testing combinations where XRF readings were equal to or greater than 1.0 mg/cm^2. The "Multifamily Housing: LBP Testing Data Sheet" was updated to include the laboratory results. Paint-chip samples were taken from 28 sampling locations: 9 shelves, 3 window casings, and 16 hall cabinets were classified as inconclusive but had XRF readings equal to or greater than 1.0 mg/cm^2. The paint-chip samples were collected from a 4-square-inch surface area on each component. Efforts were made to obtain all of the paint from each sampled area and to avoid collecting any of the substrate. Each paint-chip sample was placed in a plastic bottle, labeled and sealed, and sent to the laboratory for analysis.

The laboratory returned the results to the inspector technician who entered the laboratory results and classifications on the appropriate "Multifamily Housing LBP Testing Data Sheet" (Figure 7.19). The laboratory results of all nine paint-chip samples taken from the shelves and the three samples taken from the window casings were classified as negative. The results of 5 samples taken from the hall cabinets were classified as positive and the remaining 11 samples were classified as negative.

The "Multifamily Decision Flowchart" was applied to the results shown in the "Multifamily Housing: Component Type Report" to determine the appropriate result for each component type. The inspector technician classified all shelves and window casings as negative, based either on the XRF-corrected readings or on laboratory confirmation analysis. Therefore, no further action was required for the shelves and window casings. However, approximately 8.3 percent (5 confirmed positive results out of the 60 that were inspected) of all hall cabinets in the housing development had lead-based paint at levels equal to or greater than 1.0 mg/cm^2.

Final decisions made by the development owner regarding the hall cabinets were based on various factors, including:

- Regulatory requirements for the type of housing development.
- The cost of inspecting all hall cabinets in the development versus replacing all hall cabinets.
- Future plans, such as renovation or remodeling.
- Requirements regarding the purchase or sale of real estate.

In this case, the owner arranged for testing of the hall cabinets in all of the unsampled units to determine which were positive.

To verify the accuracy of the inspection services, the owner asked the inspector technician to retest 10 testing combinations. The retest was performed according to instructions obtained from the *XRF Performance Characteristics Sheet* (Figure 7.20). The owner appointed an employee to randomly select 10 testing combinations from the inventory list of 2 randomly selected units. The employee then observed the inspector technician retesting the 10 selected testing combinations, using the same XRF instrument and procedures as were used for the initial inspection. An XRF result (a single XRF reading) was taken from each of the 10 testing combinations. The average of the 10 repeat XRF results was computed to be 0.674 mg/cm^2 and the average of the 10 previous XRF results was computed to be 0.872 mg/cm^2. The absolute difference between the two averages was computed to be 0.198 mg/cm^2 (0.872 minus 0.674). The Retest Tolerance Limit, using the formula described in the *XRF Performance Characteristics Sheet* (Figure 7.20), was computed to be 0.231 mg/cm^2. Since 0.198 is less than 0.231, it was concluded that the inspection had been performed competently. The final summary report also included the address of the inspected units,

Multifamily Housing LBP Testing Data Sheet

Page 3 of 5

Address/Unit No. Sun City Housing Complex Date March 16, 1995

Room Equivalent Bedroom

XRF Serial No. RC-2100 Inspector Signature Joseph Smith

Substrate	Component	Color	Replication Number	Test Location	XRF Reading	Correction Value	Corrected Reading	Classification (pos. neg. Inc)	Laboratory Result	UNIT?	Laboratory Classification
Concrete	Ceiling Beam	White	1	Wall 1	0.891	N/A	N/A	INC	N/A	mg/cm² %	
Wood	Door	Brown	2	Closet Door	1.126	N/A	N/A	INC	N/A	mg/cm² %	
Plaster	Walls	White	4	Wall 1	0.261	N/A	N/A	NEG	N/A	mg/cm² %	
Wood	Window Casing	Brown	1	Wall 3	1.211	N/A	N/A	INC	0.552	mg/cm² %	NEG
Wood	Door Frame	Green	2	Wall 4	2.531	N/A	N/A	POS	N/A	mg/cm² %	
Wood	Shelves	Green	3	Wall 2, side	0.221	N/A	N/A	NEG	N/A	mg/cm² %	
Concrete	Support Column	White	2	Corner of Walls 2 and 3	0.101	N/A	N/A	NEG	N/A	mg/cm² %	
Metal	Radiator	Brown	1	Wall 1	0.736	N/A	N/A	INC	N/A	mg/cm² %	
										mg/cm² %	
										mg/cm² %	
										mg/cm² %	
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Form 7.5

Figure 7.19 Multifamily Housing LBP Testing Example: "Multifamily Housing LBP Testing Data Sheet" form completed through Laboratory Classification.

INSTRUCTIONS FOR EVALUATING XRF TESTING:

Identify a development or house for retesting. In single-family housing, an XRF result is the average of three readings taken on a testing combination. In multifamily housing, an XRF result is a single reading taken on a testing combination. If a multifamily housing development is being retested, randomly select two units from within the development from which the ten testing combinations should be randomly selected.

Randomly select ten testing combinations for retesting from each house or from the two selected units.

Conduct XRF retesting at the ten testing combinations selected for retesting.

Determine if the two units or house passed or failed the test by applying the steps below.

Compute the Retest Tolerance Limit by the following steps:

Determine XRF results for the original and repeat XRF readings. Do not correct the original or retest readings for substrate bias. There will be ten such XRF results for each house or for the two selected units.

Compute the square of each of the ten XRF results.

Add these squares of XRF results together. Call this result C.

Multiply the number C by 0.0072. Call this result D.

Add the number 0.032 to D. Call this result E.

Take the square root of E. Call this result F.

Multiply F by 1.645. The result is the Retest Tolerance Limit.

Compute the overall average of all ten original XRF results over all ten testing combinations selected for retesting.

Compute the overall average of all ten repeat XRF results over all ten testing combinations selected for retesting.

Take the difference of the overall average of the ten original XRF results and the overall average of the ten repeat XRF results. If the difference is negative, drop the negative sign.

If the difference of the overall averages is less than the Retest Tolerance Limit, the inspection has passed the retest. If the difference of the overall averages equals or exceeds the Retest Tolerance Limit, this procedure should be repeated with ten new testing combinations. If the difference of the overall averages is equal to or greater than the Retest Tolerance Limit a second time, then the inspection should be considered deficient.

This approach is estimated to produce a spurious result (calling for further examination when no examination is warranted) approximately 1% of the time.

Figure 7.20 Multifamily Housing LBP Testing Example: "XRF Performance Characteristics Sheet" providing an example of instructions for a specific XRF model.

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March 22, 1995

LEAD INSPECTION FINAL SUMMARY REPORT

XRF Manufacturer:	**ABC Company, Inc.**	XRF Device:	**XRF I**
Operator:	**Joseph Smith**	XRF Serial No.:	**RC-2100**
License Number:	**ABC123**		
Inspection Date:	**March 16-30, 1995** **7:00 a.m. to 4:00 p.m. each day**	Inspection Site:	**Sun City Housing** **Newtown, Maryland**

Eighty different testing combinations were tested in 35 units within the above identified multifamily housing development. Lead in quantities greater than the HUD standard was found in paint on the following surfaces:

Substrate	Component
Wood	Doors
Wood	Window stools
Wood	Door casings
Wood	Hall cabinets
Concrete	Support columns
Concrete	Ceiling beams
Metal	Gutters
Brick	Stairways

Figure 7.21 Multifamily Housing LBP Testing Example: Lead Inspection Final Summary Report.

the date(s) of inspection, and the starting and ending times for each inspected unit (Figure 7.21).

VI. Laboratory Testing for Lead in Paint

A. Collection of Paint-Chip Samples

For XRF results that fall into the inconclusive range and for areas that cannot be tested using XRF instruments, a paint-chip sample should be removed and sent to a laboratory for lead determination. Results should be reported in mg/cm^2, the primary unit of measure. Results should only be reported as percent by weight if the dimensions of the surface area cannot be accurately measured or if all paint within the sampled area cannot be appropriately removed. In these cases, results should not be reported in mg/cm^2, but in µg/g or weight percent.

If it is necessary to remove a paint-chip sample for laboratory analysis, only one paint-chip sample is needed for each testing combination. The paint-chip sample location should be representative of the paint on the entire testing combination. If the testing combination is replicated, one representative paint-chip sample should be taken from one randomly selected replicate.

Collection of at least a 4-square-inch area is recommended to ensure that the laboratory has a sufficient sample to conduct the analysis and that it is representative of the testing combination being sampled. Samples should be collected in sealable rigid containers such as screwtop, plastic centrifuge tubes rather than plastic bags which generate static electricity. Paint-chip collection should include, as a priority, collection of all the paint layers from the substrate, while minimizing any collection of actual substrate. If substantial substrate material is included, results should definitely be reported in mg/cm^2 to avoid a downward bias in results. Refer to ASTM ES 28–94 and Appendix 13 for further details on collection of paint-chip samples.

B. Laboratory Analysis

Several standard laboratory technologies are useful in quantitatively assessing lead levels in paint-chip samples. These methods include, but are not limited to, Atomic Absorption Spectroscopy (AAS) and Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP-AES). The dimensions of the surface area of the paint-chip sample must be accurately measured to allow laboratories to report results in mg/cm^2, as XRF instruments do. Laboratories may also report results in percent by weight measurements if, for technical reasons, reporting lead in mg/cm^2 is not feasible. Percent by weight measurements are usually reported as micrograms per gram (µg/g), milligrams per kilogram (mg/kg), or parts per million (ppm) by weight. For example, a sample with 0.2 percent lead may be reported as 2,000 µg/g, 2,000 mg/kg, or 2,000 ppm.

For analytical methods that require sample digestion, it is recommended that samples be pulverized to provide adequate surface area to obtain effective solubilization of the samples prior to laboratory instrument measurement. As stated in this chapter, paint-chip samples should be collected from a 4-square-inch surface area, which should provide the minimum amount of paint needed for a laboratory analysis. In some cases, the amount of paint collected from a 4-square-inch area may exceed the amount of paint that can be analyzed successfully. It is important that the actual sample mass analyzed does not exceed the maximum mass the laboratory has successfully tested using the specified method. If subsampling is necessary to meet the analytical method specifications, the laboratory must homogenize the paint-chip sample unless all of the sample will eventually be analyzed and the results of the subsamples combined. Any subsampling without homogenization would likely result in subsampling bias and inaccurate lead results.

If the sample is properly homogenized and substrate inclusion is negligible, the result can be reported in either milligrams per square centimeter (mg/cm^2) or percent by weight or both.

To report the results in milligrams per square centimeter, the following equation should be used.

$$\text{mg/cm}^2 = \frac{\text{weight of lead from subsample (in mg)} \times \dfrac{\text{total sample weight}}{\text{subsample weight}}}{\text{sample area (in cm}^2\text{)}}$$

To report results in micrograms per gram (µg/g), the following equation should be used.

$$\mu\text{g/g} = \frac{\text{weight of lead from subsample (in } \mu\text{g)}}{\text{subsample weight (in g)}}$$

Regardless of the method utilized for the analysis of paint-chip samples (including grinding, homogenization, and digestion), it is important that the method be demonstrated successfully by the laboratory before the analysis of any field samples. Methods should be applied to paint-chip materials of approximately the same mass as those samples anticipated in the field.

Because of the potential for sample mass to affect lead readings, reference materials processed with field samples for calibration check should be close to the same mass as those used for paint-chip samples. Refer to ASTM ES 37–94 or equivalent methods for further details on laboratory preparation of paint-chip samples.

C. Laboratory Selection

A laboratory recognized by NLLAP should be used for lead-based paint analysis. NLLAP has been established by EPA's Office of Pollution Prevention and Toxics (OPPT) in order to provide the public with a list of recommended laboratories that are capable of analyzing for lead in paint, dust, and soil samples at the levels of concern stated in these *Guidelines*. In order to participate in NLLAP, a laboratory must:

1. Participate in the Environmental Lead Proficiency Analytical Testing Program (ELPAT). The ELPAT Program is administered by the American Industrial Hygiene Association (AIHA) in cooperation with the Centers for Disease Control and Prevention (CDC), National Institute for Occupational Safety and Health (NIOSH), and OPPT. The proficiency testing samples used in the ELPAT Program consist of variable levels of lead in paint, dust, and soil matrices. (It is *not* necessary for laboratories who wish to participate in the ELPAT Program to seek accreditation by AIHA.)

2. Undergo a systems audit, including site visits. The systems audit must be conducted by an accrediting organization with a program recognized by EPA through a Memorandum of Understanding (MOU). The MOU delineates specific EPA criteria to be incorporated in the accrediting organization's assessment program for the laboratory analysis of paint, dust, and soil samples for lead.

An up-to-date list of laboratories recognized by EPA for analysis of paint-chip samples may be obtained from the National Lead Information Center Clearinghouse by calling 1–800–424–LEAD. As of January 1995, the American Association for Laboratory Accreditation (AALA) and AIHA have been recognized as laboratory-accrediting organizations participating in NLLAP. NLLAP specifies quality control and data reporting requirements, as described in "Laboratory Quality System Requirements," which can be found in Appendix A of the model MOU. The NLLAP model MOU can also be obtained by calling the National Lead Information Center Clearinghouse.

VII. REFERENCES

[1] CFR, title 10, chapter 1, subpart D (2), pp 20–9.

[2] U.S. Department of Health, Education, and Welfare, *Radiological Health Handbook*, Bureau of Radiological Health, Rockville, MD 20852, Revised Edition, January 1970, Publication No. 2016, pp. 131.

[3] State of Wisconsin, Department of Health and Social Services, memo from Mark Chamberlain dated April 28, 1994. Measurements showed that exposures to radiation during operation of a Scitec MAP 3 XRF were 132 µREM/day, which can be compared to about 1,400 µREM/day from natural background radiation.

Single-Family Housing LBP Testing Data Sheet

Page _____ of _____

Address/Unit No. ______________________ Date ______________

Room Equivalent ______________________

XRF Serial No. ______________ Inspector Signature ______________

Substrate	Component	Color	Test Locations	XRF Reading	Correction Value	Result	Classification (pos, neg, inc)	Laboratory Result	UNIT?	Final Classification
									mg/cm^2 %	
									mg/cm^2 %	
									mg/cm^2 %	
									mg/cm^2 %	
									mg/cm^2 %	
									mg/cm^2 %	
									mg/cm^2 %	
									mg/cm^2 %	
									mg/cm^2 %	

Form 7.1

SINGLE-FAMILY HOUSING LBP TESTING DATA SHEET

DEFINITIONS:

Room Equivalent: The location such as a room, a house exterior side, or an exterior area. Each side of the house, an exterior area such as a playground, hallway, and a stairway are all room equivalent examples.

Component: Components make up the sum and substance of the room equivalent. Examples are baseboards, window casing, doors, walls, ceilings, shelves, and floors.

Color: Observed paint color. One or more colors may be observed when the paint is peeling or the substrate is damaged. For example, "white" or "blue over green" could be color entries.

Test Location: The location on the surface of a testing combination where the paint will be measured for lead content.

XRF Readings: The readings made by the XRF instrument on the specified location.

Correction Value: The average of the six readings (three per location) taken from two randomly selected locations for each substrate type. These locations had the paint scraped off the substrate.

Result: Either the XRF reading average or the average minus the correction value.

Classification: A classification of the XRF result. The possible entries are: POS for positive results, NEG for negative results, INC for inconclusive results, or N/A for not available or not able to make reading. Given below are the rules for classifying the corrected reading. The upper and lower limits are obtained from the *XRF Performance Characteristics Sheet*.

- A result is **POSITIVE** if the XRF result is equal to or greater than the upper limit in mg/cm^2.
- A result is **INCONCLUSIVE** if the XRF result is less than upper limit in mg/cm^2 and greater than lower limit in mg/cm^2.
- A result is **NEGATIVE** if the XRF result is equal to or less than lower limit in mg/cm^2.

Laboratory Result: The laboratory analysis result measured in mg/cm^2 units or by percent by weight.

Unit: Circle the correct unit of measure.

Final Classification: A final classification of the tested component. The final classification should be the same as the laboratory analysis result if available, otherwise, it should be based on the XRF result. The possible entries are POS for positive results and NEG for negative results. (Note: Any inconclusive XRF result requires a laboratory confirmation and therefore is not to be used as a final classification). Given below are the rules for the final classification of the tested component.

- A result is **POSITIVE** if the XRF result is equal to or greater than the upper limit in mg/cm^2 or if the laboratory result is equal to or greater than: 1) 0.5% lead if the result is reported in units of percent by weight, or 2) 1.0 mg/cm^2 if the result is reported in area units.

- A result is **NEGATIVE** if the XRF result is equal to or less than lower limit in mg/cm^2 or if the laboratory result is less than: 1) 0.5% lead if the result is reported in units of percent by weight, or 2) 1.0 mg/cm^2 if the result is reported in area units.

Calibration Check Test Results

Page ____ of ____

Address/Unit No. ____

____

Device ____

Date ____________________ XRF Serial No. ____________________

Contractor ____

Inspector ____

Inspector Signature ____

Calibration Check Tolerance Used ____________

First Calibration Check

Red NIST SRM 1.02 mg/cm²			First Average	Difference Between First Average and 1.02 mg/cm²*
First Reading	Second Reading	Third Reading		

Second Calibration Check

Red NIST SRM 1.02 mg/cm²			Second Average	Difference Between Second Average and 1.02 mg/cm²*
First Reading	Second Reading	Third Reading		

Third Calibration Check *(If required)*

Red NIST SRM 1.02 mg/cm²			Third Average	Difference Between Third Average and 1.02 mg/cm²*
First Reading	Second Reading	Third Reading		

Fourth Calibration Check *(If required)*

Red NIST SRM 1.02 mg/cm²			Fourth Average	Difference Between Fourth Average and 1.02 mg/cm²*
First Reading	Second Reading	Third Reading		

* If the difference of the Calibration Check Average from the red NIST SRM 1.02 mg/cm² film value is greater than the specified Calibration Check Tolerance for this device, consult the manufacturer's recommendations to bring the instrument back into control. Retest all testing combinations tested since the last successful Calibration Check test.

Form 7.2

Substrate Correction Values

Page ____ of ____

Address/Unit No. ____

____

Date ____________________ XRF Serial No. ____________________

Inspector Signature ____

Use this form when the *XRF Performance Characteristics Sheet* indicates that correction for substrate bias is needed

Substrate			Brick	Concrete	Drywall	Metal	Plaster	Wood
Location	1	First Reading						
		Second Reading						
		Third Reading						
	2	First Reading						
		Second Reading						
		Third Reading						
Correction Values (Average of the Six Readings)								

Transfer Correction Values to the 'Correction Value' column of the LBP Testing Data Sheet form corresponding to each substrate.

Notes:

Form 7.3

Selection of Units

Page _____ of _____

Testing Site ____ Date ________________

Total Number of Units	Random Number*	Random Number times Total Number of Units Product	Round up for Unit Number to Sample	Sample Number

* Obtained from a hand-held calculator

Form 7.4

Multifamily Housing LBP Testing Data Sheet

Page ______ of ______

Address/Unit No. ______________________________ Date ______________

Room Equivalent ______________________________

XRF Serial No. ______________ Inspector Signature ______________

Substrate	Component	Color	Replication Number	Test Location	XRF Reading	Correction Value	Corrected Reading	Classification (pos, neg, inc)	Laboratory Result	UNIT?	Laboratory Classification
										mg/cm^2 %	
										mg/cm^2 %	
										mg/cm^2 %	
										mg/cm^2 %	
										mg/cm^2 %	
										mg/cm^2 %	
										mg/cm^2 %	
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										mg/cm^2 %	
										mg/cm^2 %	
										mg/cm^2 %	

Form 7.5

MULTIFAMILY HOUSING LBP TESTING DATA SHEET

DEFINITIONS:

Room Equivalent: The location such as a room, a house exterior side, or an exterior area. Each side of the house, an exterior area such as a playground, hallway, and a stairway are all room equivalent examples.

Component: Components make up the sum and substance of the room equivalent. Examples are baseboards, window casing, doors, walls, ceilings, shelves, and floors.

Color: Observed paint color. One or more colors may be observed when the paint is peeling or the substrate is damaged. For example, "white" or "blue over green" could be color entries.

No. of Replications: The number of times a specific room equivalent, component, substrate, and color combination occurs. For example, if four walls are characterized by the same testing combination, the number of replications would be four.

Test Location: The location on the surface of a testing combination where the paint will be measured for lead content.

XRF Reading: A single XRF reading on a testing combination.

Correction Value: The average of the six readings (three per location) taken from two selected locations for each substrate type. These locations had the paint scraped off the substrate.

Result: Either the XRF reading or the reading minus the correction value.

Classification: A classification of the XRF result. The possible entries are: POS for positive results, NEG for negative results, INC for inconclusive results, or N/A for not available or not able to make reading. Given below are the rules for classifying the corrected reading. The upper and lower limits are obtained from the *XRF Performance Characteristics Sheet*.

- A result is **POSITIVE** if the XRF result is equal to or greater than the upper limit in mg/cm^2.
- A result is **INCONCLUSIVE** if the XRF result is less than upper limit in mg/cm^2 and greater than lower limit in mg/cm^2.
- A result is **NEGATIVE** if the XRF result is equal to or less than lower limit in mg/cm^2.

Laboratory Result: The laboratory analysis result in mg/cm^2 or percent by weight.

Unit: Circle the correct unit of measure.

Lab Classification: The final classification for those testing combinations that require laboratory analysis. Given below are the rules for the final classification of the tested component.

- A result is **POSITIVE** if the laboratory result is equal to or greater than: 1) 0.5% lead if the result is reported in units of percent by weight, or 2) 1.0 mg/cm^2 if the result is reported in area units.

- A result is **NEGATIVE** if the laboratory result is less than: 1) 0.5% lead if the result is reported in units of percent by weight, or 2) 1.0 mg/cm^2 if the result is reported in area units.

Multifamily Housing: Component Type Report

Page ___ of

Address/Unit No. ____

____

Date ____________________ XRF Serial No. ____________________

Inspector Signature ____

Description	Total Number	POSITIVE		INCONCLUSIVE				NEGATIVE		Final Class
				< 1.0 mg/cm²		≥ 1.0 mg/cm²				
		Number	Percent	Number	Percent	Number	Percent	Number	Percent	

Form 7.6

MULTIFAMILY HOUSING: COMPONENT TYPE REPORT

DEFINITIONS:

Description: A description of the component type. A component type is an aggregation of testing combinations that are similar in substrate and component and sometimes color of the paint. The description should include the substrate, component, and color, if necessary. Examples are wood baseboards, yellow window casing, metal doors, plaster walls, white drywall ceilings, wood shelves, and concrete floors.

Total Number: The total number of all locations in this component by substrate classification. **The total number must be at least 40.** If this number is less than 40, continue to test additional locations of like components composed of the same substrate until at least 40 locations have been tested.

Positive Number. The total number of testing combinations classified as positive for the component type.

Positive Percent: The percentage of positive classifications.

Inconclusive Number < 1.0 mg/cm²: The total number of XRF results which fall in the inconclusive range and have XRF results less than 1.0 mg/cm.²

Inconclusive Percent < 1.0 mg/cm²: The percent of XRF results which fall in the inconclusive range and have XRF results less than 1.0 mg/cm.²

Inconclusive Number ≥ 1.0 mg/cm²: The total number of XRF results which fall in the inconclusive range and have XRF results equal to or greater than 1.0 mg/cm.²

Inconclusive Percent ≥ 1.0 mg/cm²: The percent of XRF results which fall in the inconclusive range and have XRF results equal to or greater than 1.0 mg/cm.²

Negative Number: The total number of testing combinations classified as negative for the component type.

Negative Percent: The percentage of negative classifications.

Final Class.: The final classification relative to the HUD standard of a component type based on either the Multifamily Decision Flowchart, laboratory results, or both.